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Contents

In This Issue

In the fifth of the Journal's series of essays on agricultural economics as discipline, Paul Thompson assesses the growing interest in agricultural ethics. He sees trends in philosophy, economics, and agriculture converging on policies relating to the environment, food safety, farm structure, taxes, and subsidies. He credits rural sociologists with accommodating ethical issues in analyses and policy evaluation earlier than their colleagues in agricultural economics.

Although agricultural economics has a long history of touching ethical issues in the conduct of its research, it has done little to formally assimilate the ethics branch of philosophy. Ethics might be helpful in addressing choice, fairness, equity, and legitimacy. Value theory, the heart of ethics, provides a useful context for the preference concepts of economics. Fairness may be a better approach to agricultural policy than some of the efficiency-directed analysis. Utility, philosophers remind us, isn't everything. Even a light familiarity with the literature of ethics will provide a better understanding of some of the basic premises of economics. Perhaps Thompson is correct, however, in suggesting that the best way to develop a greater appreciation of another discipline is to share a policy problem.

Neither of the articles in this issue explicitly addresses ethical issues, yet both contain elements that could easily be framed as ethical concerns. If Gertel is right, a policy to contain inflation by raising interest rates could redistribute wealth out of agriculture. Hanson and Hallam explore the values of fishing in relation to water consumption for agriculture, and in another context, might extend their inquiry to the legitimacy of fishing, hunting, and the rights of game.

Gertel, in his article, explores the role of interest rates and inflation on agricultural land prices. Inflation is included as an effect on returns to land and real interest rates. Empirically, he focuses on the Midwest, hoping thus to limit nonagricultural influences on farmland prices. He concludes that the real interest rates did not significantly influence agricultural land prices before 1972, but thereafter, real interest rates were related to the runup of land prices in the late 1970's and fall of land prices in the 1980's.

Hanson and Hallam add recreational fishing to the fray that pits agriculture against other uses for water. The purpose of the Hanson/Hallam study is to determine the effect of streamflow changes on the quality of fishing as measured in days fished. They used data from the National Hunting, Fishing, and Wildlife Associated Recreation survey (Bureau of the Census) in a couple of models. They preferred the simpler model, concluding that there is a significant relationship between downstream benefits from fishing and the level of streamflow. In 17 of the study's 99 areas in the United States, an acre-foot of water will affect the quantity of fishing by more than 1 day. Twelve of these high-impact areas are in Colorado, New Mexico, Utah, and Arizona—States with substantial irrigation.

Books reviewed begin with Conway's critique of *Agricultural Productivity: Measurement and Explanation*, edited by Capalbo and Antle. Conway's review is, in itself, a mini-survey of the state-of-production analysis and measurement. His general assessment, largely complimentary, is that the book provides a good background in production theory and measurement but not necessarily the leading edge in many areas.

Hellerstein reviews the book by Bowes and Krutilla on the economics of multiple use management of public forestland. As Hyde showed in a recent issue of the Journal, many products flow from a forest and tradeoffs are the business of economists. According to Hellerstein, the Bowes/Krutilla book is a useful overview of economics applied to forest management, a good balance of analytical techniques and forest issues.

Moore says that Wahl's *Markets for Federal Water* calls for a reduction in central government's role in water allocation, and a greater role for individuals, districts, and States in creating markets for water rights. Wahl calls for a shift away from the Bureau of Reclamation mission of development and toward greater allocative efficiency, with markets as an important tool. Moore calls the book an important contribution to the reform of water institutions.

Mathia terms the book by Krueger, Michalopoulos, and Ruttan an important contribution to the literature on foreign aid and development but says that if security and political considerations had been included, the case for bilateral foreign assistance could have been enhanced. Foreign assistance, particularly in the form of agricultural research, is favored.

Purcell provides a mixed review of *The Economics of Meat Demand* edited by Buse. The book, according to Purcell, is a call for re-examination of modeling in the meat industry. Even more troubling, he says, is blind acceptance of modeling efforts by interest groups. The

book is effective in pointing out the need to model demand shifters more correctly.

Erickson's review of *Multiple Criteria Analysis for Agricultural Decisions* is more than a review. In placing the Romero and Rehman effort in perspective, she provides an interesting commentary on goals in policy analysis and argues that multilevel approaches, such as those of Candler and others, are needed. Her overall assessment of the Romero/Rehman book is that it is thorough in detail but deficient in organization and readability.

Again, I would encourage you to read carefully the essay on ethics and agricultural economics by Thompson. We do not encourage our essayists to reference extensively. However, an examination of recent issues of the *Journal of Agricultural Ethics* or *Agriculture and Human Values* is a good place to start. For economists wishing to begin a bit further back, I recommend *The Theory of Moral Sentiments* (1759) where philosopher Adam Smith first introduced the concept of the "invisible hand" a full 17 years before he published "The Wealth of Nations." The moral of this ethical story is that there may be some great ideas in the ethics literature waiting to bloom in agricultural economics.

Gene Wunderlich

Agricultural Ethics and Economics

Paul B. Thompson

After decades of mutual disinterest, philosophers and economists have suddenly discovered extensive areas of overlap in their disciplines. An upsurge of interest in the ethics of agriculture has also taken place in the past decade. These two events are largely unrelated, however. Agricultural economics research needs to bring these two strands of literature together in the coming decade. Agricultural policy analysis is a promising area for this sort of work.

At least three different developments in philosophy and economics have brought the disciplines together. First, philosophers have become increasingly interested in rational choice theory, having come to see it as central to the analysis of many problems in ethics, political theory, and the philosophy of mind. Second, economists have rediscovered the relevance of culture and norms in forming the institutions requisite for economic exchange. Third, philosophers and economists have fought a series of battles over the analysis of public policy. For some time, it appeared that these battles would produce only acrimony, but as policy professionals have become more sensitive to the strengths and limitations of both economic and ethical theory, bringing both to bear upon the analysis of policy has become possible. These three areas, in turn, have precipitated an upsurge of interest in the traditional philosophy of economics, the result being many fine books, articles, and at least one journal, *Economics and Philosophy*.

Research in agricultural ethics has different origins. The publication of a series of popular books and essays criticizing agriculture first stimulated research on conceptual and ethical issues that seemed to be at the root of the criticisms. A group of rural sociologists then began to address ethical issues directly as part of an attempt to create a new sociology of agriculture. Philosophers with an interest in applied ethics and public policy began to identify world hunger and animal welfare issues as themes for a series of books and articles beginning in the early 1970's. The relevance of these themes to agriculture was, from the philosophers' perspective, accidental, but they provided a foundation for more systematic research and teaching on agricultural ethics.

Although these two broad developments, the disciplinary bridging of philosophy and economics, on the one hand, and the rise of agricultural ethics on the other, have different origins, their convergence clearly creates both an opportunity and a responsibility for agricultural economics research in the coming decade. Agricultural economists should build upon the work from the past two decades to revitalize some existing research within the discipline and to initiate important new areas of research. I shall not say much about the rising disciplinary overlap between philosophy and economics here. Hausman and McPherson (1990) have addressed some of those points, and my readers may consult some of the sources I have noted if they wish to learn more.[1]

Agricultural Ethics in the 1980's

Although recent professional work in agricultural ethics has been conducted by practitioners of many disciplines, rural sociologists and philosophers have a plurality of the entries in the emerging literature. The primary outlet for this work is the professional journal, *Agriculture and Human Values*, and more recently, *The Journal of Agricultural Ethics*. The topics covered have been quite varied, including issues of risk and consent in food safety, questions of fairness regarding U.S. agricultural labor, and attempts to understand "sustainability" as a norm. The general areas that have received the greatest coverage are the farm crisis of the 1980's, the emergence of biotechnology in agriculture, and the internationalization of agriculture. The farm crisis issues are predictable: the moral status of "family farms," compensation for failed farms, and analysis of responsibility for structural change. The issues of biotechnology span a wider area: environmental and esthetic influences, farm structure effects, and impacts upon the organization and management of agricultural research. Topics in internationalization of agriculture are more diverse still, ranging from critiques of "green revolution" approaches to agricultural development to debates on the goals for agricultural policy in the European Community.

There is no doubt, however, that Rachel Carson, Jim Hightower, Frances Moore Lappe, and Wendell Berry deserve most of the credit (or blame) for stimulating philosophical research on issues in agriculture. Prior to the publication of books such as *Silent Spring* or *The Unsettling of America*, work on agricultural ethics was pursued by a coterie of rural social scientists whose work, though sophisticated, was largely ignored by professional philosophers. The popular critics were more difficult to overlook. They blasted an agricultural

Thompson is an associate professor in the Department of Agricultural Economics, Texas A&M University, College Station.

[1]Sources are cited in the References section at the end of this essay.

establishment that had wallowed in self-praise since World War II and which had come to regard moral purity as a birthright. The establishment's reply to critics often began and ended with the claim that they were not part of (and hence could not know anything about) agriculture.

The existence of social conflict was itself interesting to sociologists, but the establishment's failure to meet the terms of the critics' arguments really precipitated most philosophers' interest in the debates. Rarely does a defender of agricultural practice challenge the factual claims of a critic. Far more typically, critics and defenders talk past one another, applying different concepts and values to their different understandings of the situation. These kinds of conceptual confusion are keenly relevant to ethical and political theory, and conceptual controversies perpetuate conflicts that philosophers are trained to analyze and, perhaps, resolve. The result: research on agricultural ethics has tended to follow controversial topics. This research has not been driven by any comprehensive method or theory but by subject matter. As a result, many of the generalized attempts to state "what ethics can offer agricultural economists" (including more than one that I have written myself) are not very good. The ethics literature is far better at talking about the problems than at talking about itself. The most productive approach, therefore, may be to examine the 1983 farm crisis as a case study in agricultural ethics.

The Farm Crisis and the Economic Analysis of Agricultural Policy

The farm crisis of the 1980's has substantially different coverage in the writings of critics than in the agricultural economics literature. Noting these differences will illustrate the kinds of philosophical presumptions that ethicists want to understand. Agricultural economists have labored to document farm structural change, hoping to find variables that might explain this change. The task involves the use of production and sales data to classify U.S. farms. The bimodal analysis of U.S. farm structure reveals that low-volume, part-time operations are relatively healthy in financial terms, and the number of high-volume, capital-intensive operations are growing. Other farms (the middle group) that fall in between are declining in numbers, in their share of total farm production, and in profitability.

The bimodal analysis reveals certain ethical implications. The decline in the number of farms in the middle group can readily be interpreted as a "cost" of farm policies, usually understood in terms of the aggregate financial losses and emotional stress suffered by individuals who are forced to make adjustments involuntarily. This interpretation is well suited to a framework in which alternative policies are evaluated in a general comparison of outcomes, the relative costs and benefits of each policy proposal. Such comparisons reveal tradeoffs among the policy choices, for example, how policies that mitigate costs in terms of farm stress and financial loss can be expected to impose higher costs in other areas, to taxpayers, perhaps, or to consumers. This approach has misleadingly been called utilitarian. A true utilitarian, however, would insist upon policies that optimize the ratio of benefit to cost.

Many agricultural economists recognize that the political acceptability of policy costs will be influenced by many factors that, on the face of it, at least, appear to contradict the utilitarian insistence upon optimization. Luther Tweeten (1983, 1987), for example, has acknowledged that the family farm's historical role in the U.S. national heritage provides a valid reason for accepting less than the optimal ratio of conventional costs and benefits.

The philosophy that I attribute to economists is consequentialist, however, in the sense that it is the expected value of policy outcomes (the costs and benefits) that are compared in making an evaluation of policies. If farm structural change is seen as a crisis, we must make the ethical judgment that the total number of individual farm failures in the middle group represents unacceptable costs for public policy. This judgment may be unacceptable because the policy does not produce compensating benefits for farms in the middle group, or it may be unacceptable because the costs are too great in absolute terms without regard to compensating benefits. Decisions that produce monetarily suboptimal outcomes may be justified for a variety of reasons, but policy criteria that can be expressed in terms of expected value are consequentialist criteria.

Alternative Views of the Farm Crisis

Critics who have expressed concern about the plight of family farms during the past two decades have tended to bring very different philosophical frameworks to their understanding of the farm crisis (Thompson, 1988a). Burkhardt has published a perceptive analysis of the debate. He shows that one group of critics, including Jim Hightower and Marty Strange, have argued that recent events in agriculture constitute a crisis because they represent a foreclosure of ethically important opportunities in American society. Their view is associated with a longstanding defense of capitalism against Marxist criticisms. The standard philosophical justification of *laissez-faire* capitalism has always been that it best achieves the ideal of Government by consent of the governed. In contrast, Marxists have long held that wage workers in industrialized capitalist economies are denied autonomy because they sell their labor (themselves) to survive. Populist anticommunists have argued that American society escapes this charge because of its agrarian base. Farming was an open opportunity to all Americans, one in which they might live a poor, hardscrabble

existence, to be sure, but one in which they would be autonomous. They would "be their own boss."

Hightower and Strange see the transitions taking place in the U.S. farm sector as a crisis, not because lots of individuals are adversely affected but because the political legitimacy of *laissez-faire* capitalism is being eroded. Ironically, many economists who have attempted to respond to this criticism have mistakenly presumed that the populists are enemies of capitalism. True, the populists sanction intervention in markets for land and for agricultural commodities, and this intervention may sacrifice allocative efficiencies. The populists do not value capitalism or markets for their efficiency, however, but for their uncompromising protection of private property and individual autonomy.

From a philosopher's perspective, the populists seem to be more strongly committed to capitalism than their detractors. Populists attribute intrinsic value to capitalist institutions of property and free exchange, while many economists see them as merely instruments for assuring efficiency and growth. The populists would rather be free, but poor, than be forced to gain wealth working for bosses (not to say that they object to wages—only that the individual must have a meaningful alternative to them). By a happy coincidence, to a populist, unregulated markets also promise economic growth. Efficiency arguments, on the other hand, seem to place no intrinsic value on private property, sanctioning rather severe interference in personal autonomy when market failures can be demonstrated. Consumer sovereignty becomes a means for efficiently allocating society's resources. It is the greater satisfaction resulting from free transactions that justifies markets for the consequentialist. To the populist, consequentialism places too little emphasis upon personal autonomy.

Burkhardt finds a second kind of argument in the writings of Wendell Berry (1977), and in many of the statements made by religious leaders (Comstock). The argument is difficult to summarize, and I think that many of my economist colleagues have underestimated its force because they have limited themselves to summarized versions like Berry's (1987) or the one that follows here. The idea is that one's life activity is as potent as one's will in forming moral character, that human beings have a moral and religious duty to cultivate virtues and to shun vices, but some life roles are more conducive to this than others. Aristotle thought that only aristocrats would have the wealth and leisure time needed to cultivate the virtues, but American philosophers, like Ralph Waldo Emerson, argued that virtue is best learned by living a life in which an individual's roles are well integrated with one another and with the natural environment. Traditional farming was thought to be virtuous because family roles were integral to the economic life of the farm, and the farm itself was integrated into the cycles and requirements of nature.

Given this background, the farm crisis has nothing to do with declining numbers of farmers, with financial or emotional stress, or with the costs and benefits of farm policy. The passing of the well-integrated, virtuous life is a crisis, not only in that few can live this life of virtue, but also in that virtuous rural life disappears as a role model for those in the city to look to for inspiration. Traditional farms are not valued as instruments for producing virtue. They are valued because they are experiential prerequisites for even conceptualizing duty and virtue.

Therefore, we have a duty to preserve traditional farms (of which even Berry admits there are now few). The duty is not conditioned upon calculating the costs and benefits of doing so. This simple duty is, in this respect, like a traditional religious duty. The Christian's duty to follow God's commandments is not generally thought to be derived from the fact that following commandments produces more benefits than harms. Duty to God is a simple, direct duty, not a duty done for the sake of the consequences produced. The natural law tradition of ethical theory holds that public policy must facilitate the performance of natural duties and must never controvert natural duties.

While many people would reject the philosophical framework in which Berry develops his views on the traditional family farm, most people understand what he is talking about, which, oddly, does not hold for agricultural economists. In at least two published debates, Wendell Berry has advocated his perspective on farming against consequentially oriented agricultural economists. The issue of who "won" the debates, I think, depends upon the values one brings to reading them. What is relevant here is that Berry's interlocutors seem conceptually incapable of dealing with the family farm issue in anything but consequentialist terms. They accuse Berry of emotionalism and irrationality. It is one thing to be convinced that one's own philosophical perspective is right; it is quite another to be so closely wedded to it that one excludes the possibility for rational disagreement on philosophical frameworks.

My point is to show that the bimodal analysis of farm structure change analysis is more attuned to one philosophical approach to ethics than it is to others. Economists are not biased in the sense that they favor specific policies (though some do). Neither is the bimodal analysis biased in the sense that it favors specific interest groups. Yet, the view that the farm crisis should be understood in terms of how it affects producers exiting the middle group of farms has resulted from agricultural economics research which is not philosophically neutral. Other ways of approaching public policy place comparatively little emphasis upon how a policy influences conventional economic variables, without evaluating policy in terms of measurable costs and benefits.

Agricultural Ethics, Agricultural Economics, and Agricultural Policy

I would not endorse either the populist view or Berry's view against the conclusions of the analysis that has been favored by agricultural economists. My point in discussing the views has been to present alternatives to the consequentialist framework favored by agricultural economists, and to demonstrate the philosophical assumptions of the standard approach in agricultural economics. When the possibility of alternative policy criteria is understood, a host of important problems can be more effectively grasped. Berry and the populists, for example, prefer certain kinds of institutional arrangements regardless of the monetary consequences of adopting them.

Agricultural ethics is relevant to the institutional component of policy analysis in at least three distinct ways. First, ethics are, in one sense, institutions that have a profound effect on the performance of markets. Moral norms establish property constraints and entitlements that an economist can ill afford to ignore (Thompson, 1987). Second, as implied in my discussion of farm crisis literature, alternative philosophical frameworks can evaluate, justify, or legitimize a given policy (Thompson, 1988b). Even if one is philosophically committed to choosing policies because of the consequences they produce, one would hope that a competent, professional policy analyst would have an intellectual grasp of the rights-based, communitarian, and procedural alternatives.

The third area of relevance is more deeply philosophical. Philosophers like Kant and Rawls have tried to develop a way of asking a question that probably never occurs to most of us but whose answer is vitally important to the shaping of our public laws and policies. The point of departure is Knight's observation (Buchanan) that the kind of people we are—what we believe and desire—is strongly determined by the moral norms, the opportunities, the legal structure, and the daily practices of the society in which we live. Knowing this, how can we shape our society so that it allows us to become the sort of people that we ought to be? The question requires us to strive for a kind of objectivity that may seem paradoxical. Rawls' famous thought experiment, "the original position," is intended to present a method for approaching the question by shedding all the information that individuals have about their particular wants, desires, and life goals, but by retaining all that we know about human nature and society (including economics!), which is needed to fashion an answer. By addressing our philosophical question we can arrive at a deeper grounding for consequentialist, rights-based, communitarian, or procedural theories for evaluating public policy.

Conclusions

Wendell Berry's work on the family farm is, in my view, pointed toward this third area of relevance, one that might be called "constitutional choice," in the sense implied by Anthony Giddens. Berry wants communities that produce certain kinds of people. He thinks that rural communities of America's past did so. He is, on my reading, less interested in preserving farms than he is in preserving the philosophical values of a farming people. This preservation requires a defense of those values and of the institutions that produced them. That defense, in turn, requires an attack upon the new techniques, technologies, and management strategies that inform a farm producer's choices and form the next generation's values. The new agriculture is, on my reading of Berry's work, undermining the constitution—understood as the work habits, loyalties, space-and-time awareness, and community coherence—of American society.

Again, I will shy away from endorsing Berry's view, for I am far from sanguine about the constitution of traditional rural America. Although lack of space prevents a defense of my views, the reader should know that I think there are good historical and normative reasons why any of the authors writing on constitutional choice (Castle) provide more promising strategies than does Berry. Berry's work is important because it demonstrates the necessity of raising deep philosophical questions about agriculture. Rural social scientists neglect it at the peril of confining themselves to shallowness.

The potential for new knowledge in the three areas I have noted is great and can be enhanced by interdisciplinary research in agricultural economics and agricultural ethics. Cross-disciplinary work requires more cross-referencing of the literature, and cross-referencing means that agricultural economists will have to start reading agricultural ethics. The full potential for interdisciplinary work will not be realized until there is more collaboration among economists, philosophers, and interpretively oriented sociologists. This will require some institution building of our own, and we have a long way to go.

The American Agricultural Economics Association announced a section for contributed papers on agricultural ethics for this 1990 meeting, but none were submitted. More than 100 scholars, but only a handful of economists, attended the 1989 meeting of the Society for Food, Agriculture, and Human Values. These two incidents indicate that agricultural ethics and agricultural economics may be ships passing in the night. Neither subdiscipline can afford to continue in that vein.

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Farmland Prices and the Real Interest Rate on Farm Loans

Karl Gertel

Abstract. *While economists agree on the importance of returns to land as a determinant of farmland prices, they disagree about the role of interest rates and inflation. Analysis of farmland prices for the conterminous United States, the Corn Belt, and wheat-growing areas of Kansas showed that the real interest rate on farm mortgages had only a minimal and temporary effect on farmland prices before 1972. The real interest rate along with returns have become major determinants of farmland prices since then. Changes in the inflation rate will affect real farmland prices if nominal interest rates fail to keep up with inflation.*

Keywords. *Land prices, land returns, interest rates, distributed lag, rational lag.*

Legislative proposals for agriculture raise persistent questions about the effect of initiatives on farmland prices. A large number of national and regional studies conclude that returns to land are a principal determinant of farmland prices (*1,3,15,16,18,19*).[1] Projecting farmland prices solely from returns, however, ignores other possible influences. Both the popular press and agricultural economics literature stress the rate of interest charged on farm real estate loans and the rate of inflation. A widely held view is that high interest rates hurt farmland prices while inflation tends to raise real farmland prices. Theory supports this view. Any asset that provides a stream of returns over time will decline in value if future payments are more highly discounted. A number of theoretical studies conclude that if both returns and interest rise by the amount of the increase in the inflation rate, real land prices will climb (*1,4,18*). This rise occurs because the increase in the nominal interest rate is immediately tax deductible, while the tax on the nominal increase in land price is deferred.

Despite what theory would suggest, many econometric studies have failed to establish a strong link between inflation and real farmland prices (*1,2,14,18*). Burt's findings for Illinois cropland support the view that farmland market participants are not influenced by fluctuations in interest rates but discount expected future returns by a constant equilibrium interest rate (*2*). Other studies come to opposite conclusions about the effect of inflation and interest on farmland prices (*7,9,28*). In short, there is no consensus about the effect of inflation and interest rates on farmland prices. The decisions of farmland owners, buyers and sellers of farmland, and policymakers would be improved if economists could provide them with valid information on the relationship between interest rates, inflation, and farmland prices.

This paper shows the effect of real- or inflation-adjusted interest rates on farmland prices. Results are given for the conterminous United States, the Corn Belt, and wheat areas of Kansas. Regional and national analyses augment the number of observations available for the 1970's and 1980's. The homogeneous land use pattern in the selected regions permits enlargement of the sample size by designating subregions and pooling subregional data with time series. The findings are that the real interest rate on farmland mortgages had little or no effect on land prices prior to 1972. Real interest rates had a major effect on the decline of farmland prices in the 1980's. The rates probably influenced the rise of farmland prices in the 1970's, and are likely to continue to be important in the near future. The effect of inflation on farmland prices is not examined directly, but this effect depends mainly on the relative adjustment to inflation of expected returns to land and interest rates. The behavior of real interest rates during inflationary and deflationary periods, when combined with the findings of the effect of real interest rates on farmland prices, leads to the conclusion that the decline of the rate of inflation in the 1980's had a negative effect on real farmland prices, while the rise of inflation in the 1970's probably had a positive effect. Future changes of the inflation rate are likely to continue to affect real farmland prices if nominal interest rates do not fully adjust to inflation.

The Model

The effect of change in the rate of inflation on farmland prices depends principally on land investors' expectations of the impact of inflation on farmland returns and interest rates. If inflation is expected to have the same impact on land returns and interest rates, then except for possible income tax effects, there will be no immediate effect, although over time nominal farmland prices will change at a rate equal to the inflation rate.

To derive the above conclusion, assume constant real returns equal to X and a constant real interest rate R

Gertel is an agricultural economist with the Resources and Technology Division, ERS. The author acknowledges the contributions of Patrick Canning, ERS; Nelson Bills, Cornell University, Ithaca, NY; Robert Boxley and Fred Kuchler, ERS; Lindon Robison, Michigan State University, East Lansing; and Tonya P. Hollis, ERS.

[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

and zero inflation. The price of land, P, is given by the traditional capitalization formula P = X/R. Now introduce inflation at an annual rate I and assume that land investors expect both returns and the interest rate to fully adjust to inflation. The price of land will be equal to:

$$P = \frac{X(1+I)}{(1+R)(1+I)} + \frac{X(1+I)^2}{(1+R)^2(1+I)^2} + \frac{X(1+I)^3}{(1+R)^3(1+I)^3} + \ldots \quad (1)$$

The common factor (1+I) cancels out, and the equation is a geometric progression that sums to the traditional capitalization formula P = X/R. Inflation is not neutral if land investors expect inflation to affect returns and interest rates differently. Suppose investors expect nominal returns to land to change by $(1+I_x)$ annually, while nominal interest rates are expected to change by $(1+I_r)$. Then:

$$P = \frac{X(1+I_x)}{(1+R)(1+I_r)} + \frac{X(1+I_x)^2}{(1+R)^2(1+I_r)^2} + \frac{X(1+I_x)^3}{(1+R)^3(1+I_r)^3} + \ldots \quad (2)$$

The inflation factor no longer cancels out and equation 2a sums to:

$$P = \frac{X(1+I_x)}{R(1+I_r) + I_r - I_x}. \quad (3)$$

If $I_x > I_r$, the numerator in equation 3 will increase by more than the denominator, resulting in a one-time jump in farmland prices. If $I_r > I_x$, there will be a one-time decline. Thereafter, in both cases, nominal farmland prices will change at the rate of I_x, the expected impact of inflation on returns to land.

No studies exist on the effect of inflation on land returns.[2] Sundell concludes, however, that the adjustment of interest rates to inflation is likely to lag and be insufficient to prevent longrun impacts on real interest rates (*23*). Thus, the effect of a change in the inflation rate on farmland prices depends on whether current changes in the real interest rate due to lagging adjustment of interest rates to inflation are incorporated in the capitalization rate employed by farmland investors.

The estimating equation is designed to distinguish between three alternative hypotheses of how land investors react to a change in real interest rates:

$$H_1 = P_t = \frac{X^*_t}{R} \quad (4)$$

$$H_2 = P_t = \frac{X^*_t}{R_t} \quad (5)$$

$$H_3 = P_t = \frac{X^*_t}{R^*_t}, \quad (6)$$

where P_t is price per acre at the beginning of the year.

X^*_t is the level of future returns expected in year t. Returns are estimated in real terms at the price level prevailing at the beginning of year t. R is the real interest rate, and its various designations follow.

Hypothesis 1 (H_1) states that land investors capitalize returns by a fixed long-term equilibrium real rate of interest R and are not influenced by current real rates.

Hypothesis 2 (H_2) is the opposite of hypothesis 1 and postulates that investors capitalize returns by the current real rate of interest R_t.

Hypothesis 3 (H_3) holds that land investors capitalize returns by neither a fixed long-term rate nor a current rate but an expected real rate of interest R^*_t which is not constant.

A single estimating equation allows us to test the three hypotheses simultaneously. The tests are based on the expected values of the regression coefficients and of the constant term, which assume different values for the three hypotheses. The equation is derived from a distributed lag model in which expected returns are a weighted mean of past returns.

Burt developed the equation for a fixed capitalization rate, which is adapted here to accommodate variable interest rates. The derivation of the estimating equation is not given here to conserve space.[3] The logic of the equation and the expected values of the coefficients are explained here. The estimating equation is:

$$\text{Log } P_t = \text{Log } B_o + B_1 \text{ Log } X_t + B_2 \text{ Log } X_{t-1} + B_3 \text{ Log } P_{t-1} + B_4 \text{ Log } P_{t-2} + B_5 \text{ Log } R_t + B_6 \text{ Log } R_{t-1} + B_7 \text{ Log } R_{t-2} + e_t, \quad (7)$$

where:
P_t is price per acre in the current year,
X_t, X_{t-1} are returns per acre current and lagged,

[2]Tweeten wrote that inflation lowered the parity ratio in 1948-77 (*24*). However, his conclusion is based primarily on domestic demand for farm products. For 1967-78, Schluter and Lee come to the opposite conclusion (*21*). Gardner found no significant effect of inflation on real farm income during 1956-78, but he separated inflation from the variation of exchange rates (*5*).

[3]Derivation of the equation and of the expected values of the coefficients is available in: Karl Gertel and Patrick Canning. *Returns, Interest Rates, and Cropland Prices in Selected Regions.* TB-1778. U.S. Dept. Agr., Econ. Res. Serv., May 1990.

P_{t-1}, P_{t-2} are price per acre lagged by 1 and 2 years,
R_t, R_{t-1}, R_{t-2} are real interest rates, current and lagged by 1 and 2 years, and
e_t is the stochastic error term.

Equation 7's price per acre in the current year is a weighted geometric mean of the capitalized returns in the current and preceding years and land prices in the preceding 2 years. According to the traditional capitalization formula, an increase in returns will result in a proportionally equal increase in the price of land; that is, the elasticity of land price with respect to returns is 1. The coefficients B_1, B_2, B_3, and B_4 are proxies for expected returns. Therefore the expected value of the sum $B_1 + B_2 + B_3 + B_4 = 1$. This equality holds for all alternative hypotheses.

If hypothesis 1 is true, the coefficients for interest rates B_5, B_6, and B_7 have an expected value of zero, since land investors capitalize expected returns by a long-term equilibrium rate of interest which is embedded in the constant term B_o, and are not influenced by current rates. The constant term represents the inverse of the capitalization rate, carrying an expected positive value.

The rationale of the estimating equation under hypothesis 1 can be seen by converting equation 1 from log form to an exponential form. With the interest coefficients set at zero and the stochastic error term omitted, equation 7 is transformed into the exponential form:

$$P_t = B_o \overline{X}^{(B_1 + B_2)} P_{t-1}^{B_3} P_{t-2}^{B_4}, \quad (8)$$

where $\overline{X}$ is the weighted geometric mean of X_t and X_{t-1}.

Equation 8 says that price per acre is a geometric mean of: 1) the average of returns for the current and preceding years, multiplied by a constant which is the inverse of the capitalization rate, and 2) price per acre in the preceding 2 years.[4]

If hypothesis 2 is true, the expected value of the coefficient for the current interest rate is -1 because the elasticity of land price with respect to the current interest rate is -1.

The expected values of the coefficient of R_{t-1} is equal to the coefficient of P_{t-1}, and the expected value of the coefficient of R_{t-2} is equal to the coefficient of P_{t-2} since lagged interest rates are used to convert lagged land prices to an implict annual return. With variable interest rates, no constant term exists, so the expected value of B_o is 1.

When $B_o = 1$, $B_6 = B_3$, $B_7 = B_4$, and $B_5 = -1$, the estimating equation becomes:

$$P_t = \overline{X}^{(B_1 + B_2)} (P_{t-1} R_{t-1})^{B_3} (P_{t-2} R_{t-2})^{B_4} R_t^{-1} . \quad (9)$$

In equation 9, the annual returns that are implicit in the lagged land prices come from multiplying lagged land prices by lagged interest rates. The geometric mean of current and lagged returns is then capitalized by dividing by the current interest rate.

If hypothesis 3 is true, expected returns and expected interest rates have equal but opposite effects on land prices. Therefore, the expected value of the sum of the interest rate coefficients is equal but opposite in sign to the sum of the coefficients for returns to land. When $(B_5 + B_6 + B_7) = -(B_1 + B_2,)$, the estimating equation is:

$$P_t = \overline{X}^{(B_1 + B_2)} \overline{R}^{-(B_1 + B_2)} P_{t-1}^{B_3} P_{t-2}^{B_4}, \quad (10)$$

where $\overline{R}$ is the weighted mean of R_t, R_{t-1}, and R_{t-2}.

Equation 10 gives price per acre as the geometric mean of: 1) average returns capitalized by the average interest rate, and 2) price per acre in the preceding 2 years.

Table 1 summarizes the expected values of intercept and coefficients for the three alternative hypotheses.

Intercorrelation between the error terms of unexplained residuals is a frequent problem with such equations as 7 in which past land prices are used to explain current prices. A strong interrelationship among successive error terms may result in estimates that do not converge to a fixed level as they are computed from successively larger samples. Corrective procedures through modeling of error terms is likely to be unsatisfactory and extremely complex, especially with pooled cross-section time period samples over a short time period (*2*). First tested was serial correlation between two successive error terms (Durbin h test). If no significant relationship between two successive terms was found, a test was made for a significant relationship among three successive error terms (Breusch-Godfrey test). Where a significant interrelationship between successive error terms was found, some indication of the effect on the estimates was

[4]Assumption: empirically, all coefficients in equation 8 are positive. The coefficient of P_{t-2} was sometimes found to be negative. In such cases, the interpretation is in terms of ratios. For example, this year's land price, P_t, is the previous year's land price adjusted by the ratios P_{t-1}/P_{t-2}. For a fuller explanation, see (*2*, p. 22).

Table 1—Expected coefficients under alternative hypotheses

Coefficients and equalities	Investors capitalize expected returns by:		
	Fixed rate of interest (H_1)	Current rate of interest (H_2)	Expected rate of interest (H_3)
Intercept ($LogB_0$)	Positive	Zero	Zero
$B_1 + B_2 + B_3 + B_4$[1]	1	1	1
Current real interest (B_5)	Zero	-1	negative absolute value < 1
Equalities	$B_5 = B_6 = B_7 = 0$	$B_6 = B_3$[2] $B_7 = B_4$[2]	$-(B_5 + B_6 + B_7) = B_3 + B_4$[3]

[1]Sum of coefficient of current and lagged returns and lagged land prices.

[2]Lagged interest coefficients are equal to lagged land price coefficients for the same year.

[3]Sum of coefficients of current and lagged interest rates equal the negative of the sum of the coefficient for current and lagged returns to land.

obtained by comparing the estimates with those resulting from a procedure which corrects for correlation between two successive variables. In the case of the Corn Belt, it was also possible to develop an alternative model to compare the coefficients for interest rates with those obtained from equation 7.

Procedures and Sources of Data

The areas studied are land in farms in the conterminous United States and two regions selected because land use is homogeneous and nonfarm influences on land prices are relatively minor. The first region selected was the Corn Belt—Illinois, Iowa, Indiana, and Ohio—where corn and soybeans accounted for approximately 64 percent of all land in farms in 1982. Missouri, normally included in the Corn Belt, was excluded because just 24 percent of land in farms was harvested for corn or soybeans in 1982. The second region is the cropland area of Crop Reporting Districts (CRD's) 20, 40, and 50, in central and western Kansas (the Kansas wheat region) comprising some 6.5 million acres of harvested cropland with about 65 percent dryland wheat in 1982; heterogeneity of land use precluded using the entire State for the analysis.

Returns to Farmland

I adopted the frequent practice of using returns to farm assets as a proxy for returns to farmland (*15,19,20*). The ERS series of returns to assets (*26*) was adjusted to exclude five Standard Industrial Classes of Farms (Animal Specialty, Fruits and Nuts, Horticulture, Poultry and Eggs, and Vegetables), which accounted for approximately 25 percent of total gross receipts in 1982 but only 3 percent of land in farms (*22*). Regional returns were calculated as the weighted mean of returns per acre, including Government payments, for the principal crops (*27*). Since average returns reflect a wide range of positive and negative returns (*8, 10*) and most farmland is purchased to expand existing farms (*25*, p. 20), farmland prices are likely to be more closely related to returns to expansion buyers than to average returns. Therefore, the returns series was modified to reflect returns to expansion buyers by including only half the overhead and depreciation costs.

Farmland Prices

National and regional series of returns per acre were matched with appropriate series of price per acre. For the conterminous United States, the appropriate series was U.S. average value per acre of land and buildings. The same land price series was employed for the Corn Belt since 64 percent of land in farms in 1982 was harvested for corn and soybeans. Different series had to be matched with returns to dryland wheat for the Kansas wheat region since just 39 percent of the land in farms was harvested for dryland wheat. The series most closely representing dryland wheat was the plowland series, available through 1975, and the nonirrigated cropland series thereafter.

The Real Interest Rate

The real interest rate on farm real estate mortgages was taken as the average interest rate charged by the Federal Land Banks on new farm real estate loans less the rate of inflation measured by the GNP deflator. During the period covered by the analysis, Federal Land Banks were the principal lender of farm real estate loans (*25*).

Estimates presented in the following section are based on nominal land prices and nominal land returns. This is the appropriate procedure since derivation of equation 7 comes from equation 1 in which the effect of future inflation on expected returns and interest rates cancel out.[5] The analysis was carried out in deflated terms with similar results for most of the results presented.

Conterminous United States

Table 2 relates average U.S. price per acre to land returns, past farmland prices, and interest rates. The period 1942-72 ended just before the sharp run-up in the 1970's. The period 1942-87 helps detect changes in the coefficient because of structural change. The Durbin h test detected significant autocorrelation of residuals for 1942-72. Therefore, the robustness of the

[5]Tweeten developed a similar equation for an economy in which land earnings and land returns change with the inflation rate (*17*).

Table 2—U.S. average price per acre related to the real rate of interest on farm mortgages, returns to assets per acre, and past land prices[1]

Coefficients	1942-72		1942-87
	OLS[2]	CO[3]	OLS[2]
Constant	0.0882	0.0867	−0.0105
	(.0730)[4]	(.1086)	(.0520)
Real interest rate	− .0217	− .0258	− .0312
	(.0134)	(.0133)	(.0147)
Real interest rate, 1 year ago	− .0268	− .0283	− .0269
	(.0125)	(.0134)	(.0151)
Real interest rate, 2 years ago	.0475	.0426	.0178
	(.0128)	(.0144)	(.0147)
Returns to assets	− .0064	− .0126	.0069
	(.0191)	(.0217)	(.0245)
Returns to assets, 1 year ago	.0338	.04936	.0227
	(.0202)	(.01956)	(.0230)
Price of cropland, 1 year ago	1.4007	1.2269	1.4996
	(.1403)	(.1693)	(.1374)
Price of cropland, 2 years ago	− .4470	− .2816	− .5307
	(.1410)	(.1646)	(.1394)
Number of observations	31	31	46
Adjusted R^2	.9877	.9976	.9985
Standard error of regression	.0109	.0103	.0178
Durbin h	2.8123	1.6915	− .5116
Sum of coefficients relating to returns	.9811	.9821	.9981

[1]All variables in logs base 10.
[2]Ordinary least squares.
[3]Cochran-Orcutt procedure to correct for first-order autocorrelation of residual.
[4]Numbers in parentheses are standard errors.

results was examined by comparing the coefficients obtained from ordinary least squares with the coefficients obtained from the Cochran-Orcutt procedure which corrects for first-order autocorrelation of residuals. The coefficients obtained from the two procedures are similar in signs and magnitude. For 1942-87, the Breusch-Godfrey test indicated no first or second order of autocorrelation of the residuals. So, table 2 shows only the results for ordinary least squares (OLS).

For both 1942-72 and 1942-87, the results tend to support hypothesis 3, that land investors capitalize returns by an expected real interest rate. Under hypothesis 1, the constant term relates to the inverse of the capitalization rate and has an expected positive value. The constant terms in table 2, by contrast, generally fall below their standard errors. The coefficients for the current interest rate have the expected negative values but are well below 1 in absolute value, which would be expected if land investors capitalized returns by the current real interest rate, as stipulated by hypothesis 2. During 1942-72, the coefficient for a change of the real interest rate is negative and small for the current year and for the following year, and of the same general magnitude as the coefficients for returns as would be expected under hypothesis 3, which attaches equal importance to interest rates and returns. However, these small negative effects of rising real interest rates are almost precisely canceled out by a positive coefficient in the third year. What this result suggests is that any effects of changing real interest rates were small and temporary, a reasonable outcome for 1942-72. Although real interest rates turned negative after World War II, when double-digit inflation followed the termination of wartime economic controls, the trend for 1942-72 increased by 0.07 percentage point per year, an amount hardly detectable by farmland investors.

The negative coefficients for interest rates in current and preceding years are not offset by the much smaller positive coefficient in the third year for 1942-87. This result suggests a structural change after 1972 in which land market participants became more responsive to a change in the real interest rate, a plausible result. From 1973 to 1981, the real interest rate averaged 1.2 percent compared with 3.1 percent in the previous decade. The real interest rate rose to 7.9 percent from 1982 to 1987.

Compared with the coefficients obtained by Burt for Illinois grainland, the U.S. coefficients for returns for 1942-87 were low (*2*), suggesting possible problems with aggregating returns across diverse regions, including areas where nonfarm influences on land are important. The lower coefficient for returns for 1942-87 compared with 1942-72 is consistent with the highly variable, but generally favorable, levels of farm income in returns to farm assets during the 1980's (*13*).

The Corn Belt

Two periods are examined, 1972-86 and 1972-81 (table 3). In the 1972-81 subperiod, real interest rates were generally falling and farmland prices rising. Since the Durbin h test indicates significant autocorrelation of the residuals, results are also shown for the Cochran-Orcutt procedure which corrects for first-order autocorrelation. Results are also given for an alternative model in which land prices are related to average returns in the 5 preceding years and the real interest rate, current and lagged by 2 years. The 1-year lag was excluded in the alternative model because in nearly all regional work, the coefficient for the interest rate lagged by 1 year was not significant.

The regressions for 1972-86 showed a strong negative relationship between land prices and the real interest rate on Federal Land Bank real estate loans. The moving average model produced similar results for 1975-87. The sum of the coefficients for interest rates is of the same absolute order of magnitude as the sum of the coefficients for returns, supporting hypothesis 3. For 1972-82 regressions, which are based on equation 7, the coefficients for the real interest rates are

Table 3—Corn Belt cropland, average price per acre related to the real rate of interest on farm mortgages, returns to assets per acre, and past land prices[1]

Coefficients	1972-86		1975-87	1972-81		1975-81
	OLS[2]	CO[3]	CO[3]	OLS[2]	CO[3]	CO[3]
Constant	−0.0133	−0.0730	0.5907	−0.1094	−0.0376	−1.0249
	(.0966)[4]	(.0769)	(.3457)	(.1124)	(.1023)	(.3467)
Real interest rates	− .0798	− .0809	− .0823	.0508	− .0096	− .1538
	(.0235)	(.0197)	(.0263)	(.0515)	(.0404)	(.0600)
Real interest rate,	.0244	.0646		.0247	.0302	
1 year ago	(.0250)	(.0225)		(.0300)	(.0237)	
Real interest rate,	− .0974	− .0944	− .1288	.0120	− .0351	− .1495
2 years ago	(.0216)	(.0190)	(.0261)	(.0495)	(.0379)	(.0567)
Returns to land	.0034	.0723		.0930	.0419	
	(.0487)	(.0393)		(.0495)	(.0379)	
Returns to land,	.1515	.0984	1.0919[5]	.2210	.1678	1.7888[5]
1 years ago	(.0340)	(.0299)	(.1476)	(.0597)	(.0498)	(.1292)
Price of land,	.9666	1.2784		.9103	.5283	
1 year ago	(.1122)	(.0982)		(.1534)	(.1472)	
Price of land,	− .1390	− .4234		− .0185	.3338	
2 years ago	(.1101)	(.0941)		(.1503)	(.1494)	
Number of observations	60	60	52	40	40	28
Adjusted R^2	.9790	.9815	.8720	.9825	.9845	.8961
Standard error of regression	.0299	.0276	.0497	.0302	.0282	.00470
Durbin h	2.3607	−1.3160	1.2840[6]	5.4764	.4550	1.6594[6]
Sum of coefficients relating to returns	.9825	1.0257	1.0919	1.2060	1.0718	1.7888

[1]Comprised of Illinois, Indiana, Iowa, and Ohio. All variables in logs base 10.
[2]Ordinary least squares.
[3]Cochran-Orcutt procedure to correct for first-order autocorrelation of residual.
[4]Numbers in parentheses are standard errors.
[5]Average of 5 preceding years.
[6]Durbin-Watson statistic.

small in relation to their standard error, indicating no effect of interest rates in this period. By contrast, the moving average model results in a negative coefficient for the real interest rate of approximately the same magnitude as for 1972-86. Thus, for subperiod 1972-81, the results are unclear, but a negative effect of real interest rates on farmland prices cannot be ruled out.

The sum of current and lagged coefficients for the real interest rate is −0.15 for the OLS regression and −0.11 for the Cochran-Orcutt procedure for 1972-86. Since the coefficients of an exponential equation are elasticities, the results indicate that a 1-percent rise in real interest on farm mortgages would result in a decline of land prices of 0.11 to 0.15 percent. Thus, a 25-percent increase in the interest rate, say from 4 to 5 percent, would cause land prices to fall by 25 times 0.11 to 25 times 0.15 or approximately 3 to 4 percent. From 1981 to 1983, the real interest rate rose by almost 400 percent, which would result in an estimated fall of farmland prices of 400 times 0.11 to 400 times 0.15, or 44 to 60 percent. These numbers suggest that the rise in real interest rates was a major contributor to the decline of Corn Belt farmland prices in the 1980's.

Kansas Wheat Region

The Breusch-Godfrey test showed no significant second-order autocorrelation between residuals for 1972-86, but a second-order autocorrelation was found for 1972-81 in the Kansas wheat region (table 4). To examine the robustness of the 1972-81 coefficients, results for ordinary least squares are shown with results from the correction for first-order autocorrelation using the Cochran-Orcutt procedure. The coefficients for interest rates and returns are similar for both procedures.

A strong negative relationship existed between the real interest rate on farm mortgages and cropland prices for 1972-86. The coefficients for the 1972-81 subperiod are quite similar, suggesting that cropland prices responded to the decline of real interest rates in the 1970's and their rise in the 1980's. A dynamic pattern of response to interest rates was similar to the pattern in 1972 in the Corn Belt. The negative response to a rise in real interest rates occurs in the year in which the rates go up. There is a little response or a small recovery in the following year and a further decline 2 years after the rise in rates occurred. The reason for this pattern is unclear. Possibly the initial response in the first year is followed by a period of adjustment and of waiting for confirmation of the new real rate and a further response, as the new rate continues into the third year.

As was found for the Corn Belt, land prices respond much more to returns earned in the previous year than returns anticipated for the current year. Since USDA obtains land prices for the first quarter of the year

Table 4—Kansas wheat region cropland, average price per acre related to returns to the real rate of interest on farm mortgages, returns to assets per acre, and past land prices[1]

Coefficients	1972-86 OLS[2]	1972-81 OLS[2]	1972-81 CO[3]
Constant	−0.2291	−0.1924	−0.1177
	(.1239)[4]	(.1379)	(.1851)
Real interest rate	− .0929	− .1174	− .1440
	(.0308)	(.0674)	(.0656)
Real interest rate, 1 year ago	.0229	.0547	.0503
	(.0370)	(.0449)	(.0414)
Real interest rate, 2 years ago	− .1491	− .1545	− .1840
	(.0328)	(.0599)	(.0539)
Returns to land	.0443	.0215	.0032
	(.0352)	(.0515)	(.0519)
Returns to land, 1 year ago	.1125	.1517	.1561
	(.0346)	(.0425)	(.0500)
Price of land, 1 year ago	.7066	.5333	.3048
	(.1461)	(.1992)	(.1877)
Price of land, 2 years ago	.1522	.3046	.4737
	(.1402)	(.1707)	(.1563)
Number of observations	43	29	29
Adjusted R^2	.9625	.9662	.9621
Standard error of regression	.0365	.0373	.0364
Durbin h	− .9115	[5]	− .3150
Sum of coefficients relative to returns	1.0156	1.0111	.9371

[1]Kansas Crop Reporting Districts 20, 40, and 50. All variables in logs base 10.
[2]Ordinary least squares.
[3]Cochran-Orcutt procedure to correct for first-order autocorrelation of residuals.
[4]Numbers in parentheses are standard errors.
[5]Calculations of Durbin h not feasible because they result in negative square roots.

while returns accumulate throughout the year, this finding is consistent with the hypothesis that land market participants form expectations primarily from past returns rather than anticipated future returns. This hypothesis is consistent with the limited success of the application of rational expectations to farmland prices reported by Just and Miranowski (*12*).

Conclusions

The decisions of farmland investors and policymakers would probably improve with information on the relationship between interest rates, inflation, and farmland prices. Changes in the real interest rate had only a small and temporary effect on farmland prices during 1942-72 but were significant thereafter for the conterminous United States. Results from the Kansas wheat region showed that the decline in the real interest rate contributed to rising farmland prices during the 1970's. All three regions pointed to a rise in the real interest rate as a major contributor to the decline of farmland prices in the 1980's.

The effect of inflation on farmland prices was not investigated directly, but theory tells us that the impact of inflation on farmland prices depends mainly on the relative adjustment of land returns and real interest rates to the changed rate of inflation. A change in the real interest rate will likely produce an opposite change in farmland prices in the near future, judging by the response to changing real interest in recent decades.

The relationship between returns and land prices at the national level was weaker than at the regional level, reflecting problems of aggregating returns over diverse regions including areas where nonfarm influences were important. The response of farmland prices to a change in returns was similar and resulted in a lagged adjustment of farmland prices in the Corn Belt and the Kansas wheat region. During 1972-86, approximately 10-15 percent of the change in returns in the preceding year and 0-7 percent of the change in the current year was reflected in current land prices.

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Single-Stage and Two-Stage Decision Modeling of the Recreational Demand for Water

LeRoy T. Hansen and J. Arne Hallam

Abstract. *Past rivalry over access to water has usually been between the farmers who irrigate and new agricultural, industrial, and municipal demands. Recently, the recreational demand for water has become another consideration in water allocation decisions. We examine the significance of the recreational demand for water as a fishery resource by applying two different frameworks to the decision to fish. The consistency of the estimated responses to changes in fishery resources across both decision frameworks testifies to the importance of streams as a recreational fishery resource. Modeling behavior within the household production framework allows all downstream effects to be estimated, not just impacts at particular sites. Marginal values of water as a recreational fishery resource are estimated based on day values of fishing derived in prior research.*

Keywords. *Recreational demand, recreational fishing, stream fishing.*

Agriculture, the single largest consumer of water in the United States, will face reduced allocations of streamflow if political pressures for recreational uses of the water become significant enough. State water managers have granted agriculture ownership or rights to water. Any water reallocation must work within water laws. Water rights are, in general, based on appropriation doctrine in the Western States and the riparian doctrine in Eastern States. Neither of these doctrines prevents States from reallocating water, although the State may be obligated to compensate those who forgo water rights. For more detail on water law, see (*8*).[1]

The effect of streamflow depletions on recreational fishing is estimated for all regions in the contiguous United States. Two approaches to modeling the decision to fish are applied. The consistency of results from the two approaches provides additional support for the estimated responses to variations in streamflow. The National Hunting, Fishing, and Wildlife-Associated Recreation (FHWAR) survey, with specific questions on the respondent's recreational fishing activities, provides the necessary observations on individual behavior (*22*). The effect of streamflow depletion is measured by the change in the number of days spent fishing given an acre-foot change in annual streamflow. Responses are estimated for individuals and aggregated across the relevant (downstream) population to estimate the total change in days fished per acre-foot change in flow. The days per acre-foot responses within each State are multiplied by prior estimates of the value of a day of fishing within the respective State to approximate the recreational fishery value of an acre-foot of streamflow.

Significant difficulties hamper the estimation of the recreational benefits of water. We do not overcome all difficulties and, therefore, do not provide a bottom line value of water for recreation. We cannot assess the water's value as a fishery resource, but instead offer insight into the significance and extent of water's recreational use as a fishery resource. The regional estimates of the recreational significance of water indicate the areas where recreational benefits are most significant and suggest to water managers which policies might be most beneficial to both consumers and recreational users of water.

At least five studies have attempted to estimate the recreational fishing value of streamflow. Amirfathi and others, Daubert and Young, Walsh and others, and Ward limited their analyses to a stream segment or to a drainage basin (*1*,*6*,*23*,*24*). Johnson and Adams included the downstream recreational benefits but focused on only steelhead fish populations and not other species of fish (*10*).

Earlier works (except (*12*)) attributed fishery quality to the level of streamflow during a particular month or season, a contention that is valid only when those particular periods are most threatening to the health of the fishery. The aggregate nature of the present analysis and the "Montana Method" suggest that annual streamflow is the best indicator of the health and quality of a stream fishery (*20*). The Montana Method has shown that nature has evolved fisheries to do best in levels of pristine or natural streamflow. Natural flow is the flow that would occur without any upstream human diversions or impoundments. Depletion of streamflow reduces the productivity of the stream fishery.

Since 1964, the Montana Method has been tested in detailed field studies in many cold water and warm water streams of various sizes and across streams of various flow regimes. Fishery habitats are remarkably

Hansen is an economist with the Resources and Technology Division, ERS. Hallam is an associate professor of economics, Iowa State University, Ames. The authors thank Steve Crutchfield, Marc Ribaudo, Dick Brazee, Bruce Larson, C. Edwin Young, and other helpful reviewers.

[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article.

similar in most of the streams which carry the same portion of their average seasonal flows. Thus, reservoirs can damage fisheries by altering flow from normal seasonal variations. However, reservoirs can improve fisheries by evening up flow variations between years.[2] While better water management may improve some stream fisheries (see *23*), estimating these effects is beyond the scope of this analysis.

This study improves upon earlier studies by including the effects of streamflow depletion on all recreational fishing and including all downstream fishery effects. The recent efforts to estimate the recreational fishery value of streamflow reflects a recognition of the importance of streamflow as a recreational fishery resource. The marginal value of recreational uses of streams will grow as demand for these resources grows because, in contrast to market goods, the number of streams and rivers cannot be increased.

Preliminary Model Development

Fishing is not the only recreational use of streams, but it is considered to be the most significant (*2*). Fish live and move throughout a stream so that the stream offers a continuum of fishing sites. A change in streamflow can affect the quality of fishing at all downstream sites. Because of this, we estimate the response of streamflow changes by its impact on individuals, aggregating across individuals as opposed to measuring responses at individual sites and aggregating across sites. This same reasoning has been applied by Russell and Vaughan (water quality) and Miller and Hay (hunter participation) (*19*,*16*).

This paper models individuals behavior within the household production framework (*3*,*7*). The household production framework accounts for the household's decisions on resource allocation by emphasizing that households use time, market goods, and available public goods in the production of "commodities," intangible items that directly enter the utility function. In this case, we estimate a reduced-form commodity supply/demand equation. The recreational fishing commodity is assumed to be produced using time, the available fishery resources, and technology. Demand for the commodity is assumed to depend on personal characteristics and the availability of substitute commodities. If time spent fishing corresponds linearly with the production level of the recreational fishing commodity, then, following work by Deyak and Smith, the reduced form commodity supply/demand equation can be written as:

$$DAYS = f(FR,OR,PC), \quad (1)$$

which describes the number of days an individual spends fishing (that is, the level of recreational fishing commodity produced) as a function of the available fishery resources (FR), the availability of other recreational commodities (OR), and the personal characteristics of the individual (PC) (*7*). Since this is an equilibrium relationship determined after setting "commodity" demand equal to commodity supply, price does not appear in the equation.[3] The FHWAR survey contains information on individual fishing activities and on personal characteristics. The Water Resources Council's Second National Water Assessment (SNWA) provides data on streamflow. Other resource availability estimates are provided by the 1982 National Resources Inventory (NRI) (*20*).

Response Estimation

This analysis determines the significance of a unit of water to the downstream demand for fishery resources. The design of the FHWAR survey allows two approaches, a two-stage approach and a single-stage approach, to be used to estimate the impact of streamflow changes on the expected number of days an individual fishes. We test the significance of streamflow as a fishery resource in two different models, compare the results, and examine the significance and consistency of the estimated responses.

The FHWAR survey obtained fishing participation responses from two separate samples which generated two different data sets. The first survey screened the continental U.S. population at large. More than 340,000 respondents were asked questions on their personal characteristics and whether or not they fished in 1980. The second survey followed up on a 35,615-person subsample of those who said in the screening survey that they had fished. This second data set contains the same information on personal characteristics as the first data set. However, it provides the number of days fished and other detailed information on the individual's fishing participation.

The Two-Stage Approach

The two-stage approach views the individual's decision as a two-stage process, and thus, relies on two regression equations. In the first stage, the individual decides, for the year, whether or not to fish; the prob-

[2]Catch rates and, therefore, fishing participation can move inversely to the annual flow variations in the short run. For example, a dry year can lead to fish stocks being concentrated in small pools, and catch rates will rise. A subsequent year of more normal precipitation and flow levels can then lead to lower catch rates because of the heavy harvesting and the poor fishery conditions in the prior year. This same inverse relationship between the quality of the fishery and catch rates can be problematic to analyses relating observed flows to fishing behavior.

[3]The independent variables of the reduced-form equation are the commodity supply and demand shifters (*7*). Alternatively, a reduced-form equation can be solved for equilibrium price by equating quantity in the commodity supply/demand functions. For other applications of this approach, see (*16*,*19*).

ability of an individual fishing, P(fish), is estimated from the screening sample. In the second stage, the number of days to fish is decided; the expected number of days fished, given that the individual fished, (D|fish), is estimated from the follow-up survey. In the two-stage decision framework, the estimation of DAYS of equation 1 is described by:

$$DAYS = P(fish)*(D|fish). \quad (2)$$

The model used to estimate P(fish), the probability of fishing, is applied to the population sample and can be described as:

$$Y = g(FR,OR,PC), \quad (3)$$

where Y, the dependent variable, equals 1 if the individual fished and zero otherwise, FR is a vector of fishery resources, OR is a vector of measures of other recreational resources, and PC is a vector of personal characteristics of the individual (including income).

The model used to estimate (D|fish) is applied to the sample of those who fished and can be described similarly as:

$$Z = h(FR,OR,PC), \quad (4)$$

where Z is the number of days spent freshwater fishing (but not in the Great Lakes) and the independent variables are as described above. The probit and tobit transformations of equations 3 and 4 (discussed below) generate, respectively, P(fish) and (D|fish) of equation 2.

The Single-Stage Approach

The second approach views the individual's decision on the level of fishing as a single-stage procedure. This approach requires a population sample that includes the number of days fished by those who fished (for example, information from both the screening and follow-up survey). To get information from both the screening survey and the follow-up survey into one data set, observations in the screening survey on those who fished were replaced with a statistically representative sample of observations from the follow-up survey.[4] Thus, in the single-stage framework, equation 1 is written as:

$$W = m(FR,OR,PC), \quad (5)$$

where W is the number of days spent freshwater fishing (but not in the Great Lakes) and the independent variables are as in equations 3 and 4.

The applied methodology ignores the value side of the day spent fishing but provides information on the effect of shifts in the independent variables on the number of days fished by current and new participants. As discussed earlier, estimation of this reduced-form commodity supply and demand equation fails to provide information on price. However, marginal values for days of fishing have been estimated in previous studies (*4,9,12*) and can be applied to determine the value of marginal shifts in the independent variables.

Statistical Considerations

A probit model is applied to the yes-no fishing decision of equation 3 to estimate P(fish) (*13,14*). The statistical model used to estimate equation 4 belongs to the family of censored response models. The dependent variable in this model is days spent freshwater fishing outside of the Great Lakes, but the follow-up sample contains observations on all people who fished including those who fished only in the ocean or Great Lakes. Thus, values of Z (equation 4) are clustered at zero, indicating a censored sample and the need to apply a tobit model to estimate (D|fish) (*11*).

The single-stage estimation (equation 5) uses observations on the population where W is either zero or greater than zero. This sample is another censored sample indicating, again, the need for a tobit analysis.

Quantifying Stream and Lake Fishery Resources

The vector of fishery resources, FR, includes both lake and stream fishery resources. Lake fishery resource availability is most dependent on the surface area of lakes. Though factors such as water quality and boat wakes can affect the quality of lake fishing, these factors are not expected to have created variations in lake productivity across regions.

Biologists have found the surface area of streams within a region to be the most important factor determining the potential availability of stream fishery resource. But, the portion of streamflow depletion is also important. Cover and feeding habitat are lost and spawning beds are degraded as streamflow is depleted.

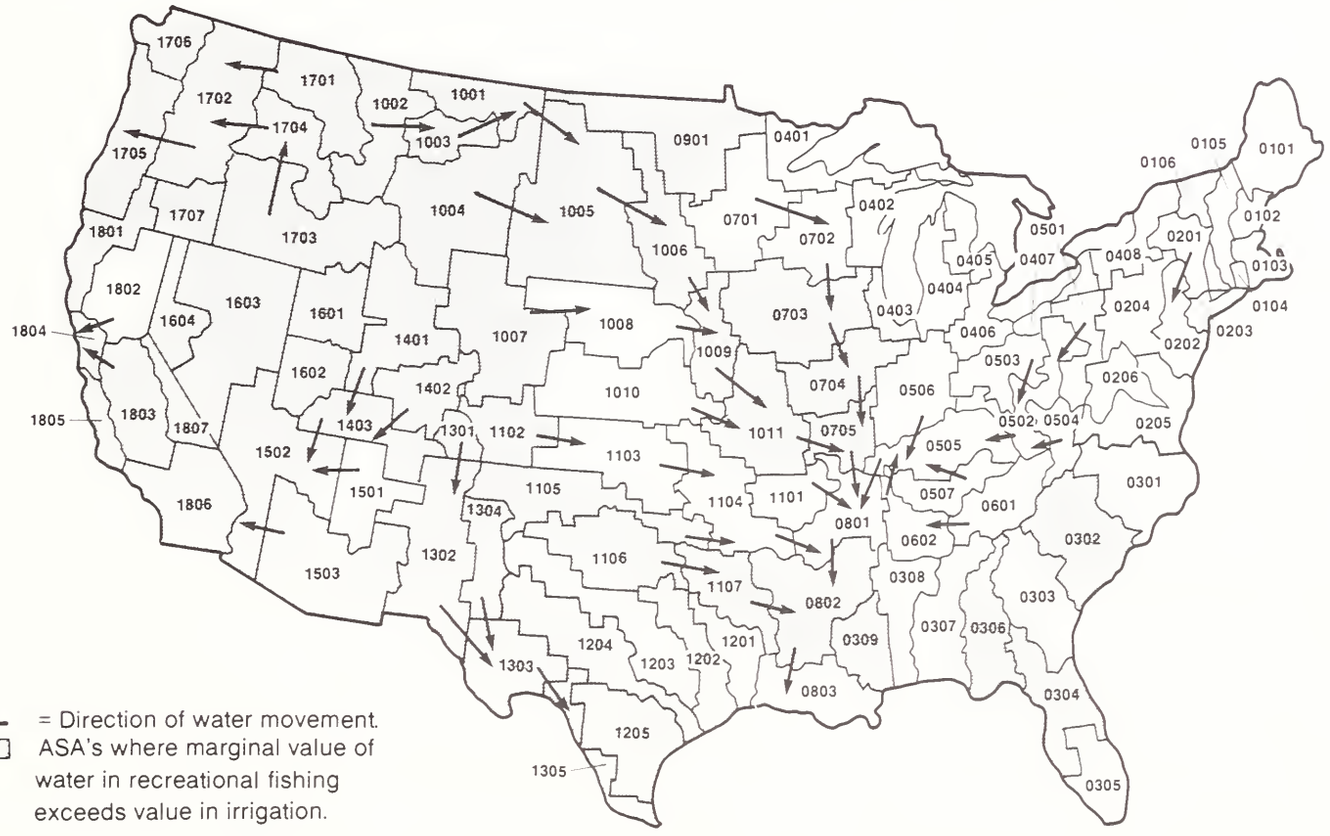
Examining the effects of streamflow depletions showed that field studies, carried out on cold water and warm water streams of various sizes throughout the United States, have proved a consistent relationship between the portion of natural flow remaining in the stream (or relative flow) and the fish standing crop (*17,19,24,25*).[5] The impact of diverting a given quantity of water per stream surface acre is more signifi-

[4]Computer capacity constraints allowed only a subsample of the population sample to be used.

[5]Fish standing crop is measured in terms of pounds of fish produced per stream surface acre.

Figure 1

Areas where marginal value of water in recreational fishing exceeds value in irrigation



Water Resource Council's Aggregated Subareas (ASA's).

cant for smaller streams because the quantity is a higher portion of the smaller stream's natural flow. However, the larger streams have a greater surface area so that the total effect of the diversion on the availability of fishery resources is unique to each region.

The SNWA provides an estimate of relative flow for each of the 99 major drainage basins, or Aggregated Subareas (ASA's), in the United States (fig. 1). The NRI furnishes county-level data on stream surface. Fishery resources within a county are estimated as the product of relative flow and stream surface acres.

The FHWAR survey divides the 48 contiguous States into 129 regions that identify where respondents live. Fishery resources potentially available in the 129 resident areas and in the FHWAR-delineated regions surrounding the resident areas are estimated by summing resources in the relevant counties.

While the surface area and relative flow indicate the productivity of streams, the availability of fishery resources to any individual depends on the fishing pressure on the available resources. Therefore, fishery resources for both streams and lakes are measured on a per capita basis.

Two other factors affecting fishery resource availability are also included. First, degradation of fish habitat due to loss of streamside tree cover is calculated based on data from the NRI. Second, the availability of stream and lake fishery resources in the surrounding regions are adjusted for distance. We do not have data on the distances individuals were from fishery resources outside of the resident areas. We know that resident areas varied in size, so average distances to resources outside the resident areas must have varied.[6] Based on the relationship between area and length (or distance), we proxy the average distance to resources outside the resident area with the square root of each resident area.

Stream and lake fishery resources of the vector FR are quantified as:

$$\begin{aligned}
STREAMIN_j &= \ln(COVER^{in} * FLOW^{in} * STREAM^{in}/POP^{in})_j \\
STREAMOUT_j &= \ln((COVER^{out} * FLOW^{out} * STREAM^{out}/POP^{out})/AREA)_j \\
LAKEIN_j &= \ln(LAKE^{in}/POP^{in})_j \\
LAKEOUT_j &= \ln((LAKE^{out}/POP^{out})/AREA), \qquad (6)
\end{aligned}$$

[6]The travel times to fishery resources within the resident areas are assumed not to vary significantly across resident regions. Any variation that does exist is assumed to be uncorrelated with variables included in the model.

where:
STEAMIN is the per capita stream fishery resources of the resident area,
STREAMOUT is the per capita stream fishery resources outside the resident area,
LAKEIN is the per capita lake fishery resources of the resident area,
LAKEOUT is the per capita lake fishery resources outside the resident area,
STREAM is stream surface area,
LAKE is lake surface area,
POP is population,
FLOW is relative flow or the portion of natural flow remaining,
COVER is 1 plus the proportion of the riparian vegetation being trees,
AREA is the square root of the total area of the resident area.
The j subscripts identify values associated with individuals in the jth resident area, and the superscripts *in* and *out* signify the resources within and outside the resident region, respectively. The natural logarithm of each of these resource measures, which tested superior to quadratic formulation, provides for diminishing marginal productivity of water resources in producing the recreational commodity.

Thus, the right-hand side of equations 3, 4, and 5 are written as:

$$\beta_0 + \beta_1 SEX + \beta_2 CITYKID + \beta_3 COUNTRYKID + \beta_4 RETIRED + \beta_5 WORK + \beta_6 INSCHOOL + \beta_7 AGE + \beta_8 AGESQUARED + \beta_9 EDUCATION + \beta_{10} HHOLDSIZE + \beta_{11} INCOME + \beta_{12} INCSQUARED + \beta_{13} URBAN + \beta_{14} SEAMILES60 + \beta_{15} SEAMILES + \beta_{16} STREAMIN + \beta_{17} LAKEIN + \beta_{18} STREAMOUT + \beta_{19} LAKEOUT, \quad (7)$$

where the β's are the regression coefficients and the variables are as defined in table 1. Both age and

Table 1—Regression results for estimating P(fish), (D|fish), and the single-stage estimation of DAYS

Variable[1]	Two-stage		Single-stage
	P(fish)	(D|fish)	DAYS
SEX	0.133	7.90	16.9
	(3.33)[2]	(8.10)	(12.1)
CITYKID	− .110	−3.08	
	(1.68)*	(2.14)	
COUNTRYKID			8.03
			(5.41)
RETIRED	.180		11.4
	(1.82)*		(3.82)
WORK		−4.11	
		(3.82)	
INSCHOOL		−4.18	9.99
		(2.42)	(3.66)
AGE	.0115		2.13
	(3.18)		(10.5)
AGESQUARED	− .000267		− .0262
	(5.38)		(10.7)
EDUCATION			.559
			(3.05)
HHOLDSIZE	.0812	−1.20	
	(6.22)	(4.39)	
INCOME	.00358	.0251	.0619
	(7.29)	(2.25)	(3.60)
INSQUARED	$-4.16*10^{-5}$	$-5.39*10^{-5}$	− .000113
	(4.89)	(2.82)	(3.74)
URBAN	− .135	−2.59	− 6.16
	(3.16)	(2.94)	(4.27)
SEAMILES60	− .155	−5.46	− 6.16
	(3.58)	(5.61)	(4.02)
SEAMILES	− .232	−5.15	−11.8
	(2.75)	(2.65)	(3.87)
STREAMIN	.0863	2.33	3.56
	(4.31)	(5.23)	(5.15)
LAKEIN	.0464	− .751	1.59
	(2.48)	(1.82)*	(2.45)
STREAMOUT		.705	1.49
		(2.53)	(3.36)
LAKEOUT		− .333	− .823
		(1.60)*	(2.52)
CONSTANT	− .146	17.3	−50.0
	(1.06)*	(6.59)	(9.41)
R-squared	.1029	.0348	.0792

[1]Variables significant at the 95-percent level unless otherwise noted.
[2]t-statistic in parentheses.
*Not significant at the 95-percent level.

income are expected to have diminishing marginal effects on days fished, so quadratic forms of these variables are included. The variables URBAN, SEAMILES60, and SEAMILES are used as proxies for prices of substitutes to the recreational fishing commodity.

Because equation 7 is a reduced-form equation, the estimated coefficients cannot be interpreted as either demand or supply structural parameters. Instead, the coefficients represent a combination of the supply and demand parameters (*7*, p. 69).

Coefficients on STREAMIN, LAKEIN, STREAMOUT, and LAKEOUT are expected to be positive. The relative sizes of coefficients on the stream and lake variables depend on which resource is the better recreational fishery resource. Coefficients on SEAMILES and SEAMILES60 are expected to be negative since the proximity of the sea or the Great Lakes directly affects the price of a substitute for freshwater non-Great Lakes fishing. The effect of the variables describing personal characteristics is discussed in (*8*) and, therefore, is not detailed here.

Results

Regression results from the two-stage analysis and the single-stage analysis both indicate that the availability of stream fishery resources is significant in explaining fishing behavior (table 1). The lack of significance of STREAMOUT in P(fish) may indicate that fishery resources that are not relatively close to home are not a significant factor in an individual's decision to fish.

Most coefficients of other variables are significant at the 99-percent confidence level and are of the expected sign. However, lake resources outside the resident region show a negative effect in the single-stage analysis. While both the LAKEIN and LAKEOUT coefficients in (D|fish) are negative, the coefficients are insignificant. One interpretation of a negative relationship between lake resource availability and days fished is that lakes are more important as an input in production of substitute recreational commodities. However, estimation of the importance of lakes in other recreational activities is beyond the scope of this analysis.

The probit and tobit coefficients in table 1 cannot be directly interpreted as marginal responses like OLS coefficients. To better compare the measures of fishing behavior obtained from the two approaches, we estimated marginal responses for some important variables for an "average" individual (table 2).[7]

[7]See (*11*) for derivation of marginal effects from probit coefficients. See (*13*) for derivation of marginal effects from tobit coefficients.

Table 1 variables and definitions

Variable	Definition
P(fish)	Binary variable: 1 if fished, 0 otherwise.
(D|fish)	Days freshwater non-Great Lakes fishing of those who did fish.
DAYS	Days freshwater non-Great Lakes fishing for any individual.
SEX	Binary variable: 1 if male, 0 otherwise.
CITYKID	Binary variable: 1 if the population of the area raised in was greater than 500,000, 0 otherwise.
COUNTRYKID	Binary variable: 1 if the population of the area raised in was less than 10,000, 0 otherwise.
RETIRED	Binary variable: 1 if retired, 0 otherwise.
WORK	Binary variable: 1 if employed, 0 otherwise.
INSCHOOL	Binary variable: 1 if in school, 0 otherwise.
AGE	Age in years.
AGESQUARED	Age in years squared.
EDUCATION	Number of years attended school.
HHOLDSIZE	Number of people living in household.
INCOME	Income as a midpoint of (in $1,000): 0-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-40, 40-50, and 57.5 otherwise.
INCSQUARED	Income squared.
URBAN	Binary variable: 1 if 1980 Census classified area of resident as urban, 0 otherwise.
SEAMILES60	Binary variable: 1 if ocean or Great Lakes fishing is within 60 miles, 0 otherwise.
SEAMILES	Binary variable: 1 if ocean or Great Lakes fishing is within 120 miles but over 60 miles, 0 otherwise.
STREAMIN	Per capita stream fishery resources of the resident area.
STREAMOUT	Per capita stream fishery resources outside the resident area.
LAKEIN	Per capita lake fishery resources of the resident area.
LAKEOUT	Per capita lake fishery resources outside the resident area.
CONSTANT	Regression constant.

Table 2—Marginal effects for changes in selected variables

Variables[1]	Approaches	
	Two-stage	Single-stage
SEX	2.79	4.52
INCOME	− .0728	.00406
URBAN	−1.47	−1.65
SEAMILES	−2.73	−3.15
STREAM	$2.52*10^{-6}$	$2.13*10^{-6}$
LAKE	$1.07*10^{-8}$	$1.11*10^{-7}$
FLOW	.0130	.0110

[1]Variables defined in table 1 and equation 1.

The coefficient of determination (the R-square that is the ratio of explained to unexplained variation in the dependent variable) is not close to 1 for any of the estimated equations. But, a low R-square is characteristic of qualitative choice models. For example, Morrison has shown that with a binomial dependent variable where the probability of a success is 0.40, the maximum possible R-square is 0.167 (*17*, p. 70).

Marginal Responses to Stream Fishery Resource Availability

The change in days fished for a 1-percent change in streamflow is 0.0130 in the two-stage approach and is 0.0110 in the single-stage approach (table 2). This consistency across approaches enhances the likelihood that our estimated coefficients approximate the true relationship. Results from the single-stage approach are selected as superior to the responses estimated from the two-stage approach because of the low coefficients of determination for the P(fish) and (D|fish).[8] Estimating a single equation prevents losses in degrees of freedom.

For a better understanding of the change in days fished for a change in streamflow, marginal responses of the single-stage analysis are translated to a day-per-acre-foot estimate for each river basin. Responses within each drainage basin are totaled to provide an estimate of the total change in days fished for a 1-percent change in streamflow. Using the water volume associated with a 1-percent change in flow (provided by the SNWA), we determined the total population response for an acre-foot change in streamflow (table 3).

Table 3 indicates a considerable variation in the marginal effect of an acre-foot of streamflow. However, this variation is consistent with what one would expect. For example, in the southern half of Louisiana, which lies mostly in ASA 0803 (fig. 1), an additional acre-foot depletion of streamflow is estimated to reduce the number of days fished by all who might fish the waters a total of 0.008 day. Considerably farther upstream, in southern Nebraska, northern Kansas, and northeastern Colorado (ASA 1010 in table 3), the diversion of an acre-foot of water decreases the number of days people fish by an estimated 0.889 day. An acre-foot depletion of flow has a greater impact in the Plains than in Louisiana for three reasons. First, an acre-foot of water does not represent as significant a portion of total flow in Louisiana and, therefore, has a smaller impact on fishing opportunities. Second, because Louisiana has an abundance of fishing opportunities, marginal effects are small. Third, the estimated effect of depleting an acre-foot of water in the Plains must include the impact of one less acre-foot in all downstream ASA's (including effects in Louisiana).

The marginal response to an acre-foot change in streamflow is less than half a day in 69 of the 99 ASA's. The more water-abundant Eastern States tend to have the lower marginal responses despite the higher population densities. The ASA that contains Chicago, ASA 0403, has a relatively high marginal response at 2.4 which is probably due, in part, to the 25-percent depleted streamflow and the high population density.

Twelve of the 17 ASA's that have marginal responses greater than 1 lie primarily in Colorado, New Mexico, Utah, and Arizona. Each of these States makes extensive use of streamflow for irrigation. Although these States are not densely populated, the lack in availability of streamflow tends to result in high marginal water values. Less confidence should be placed in the response estimates for 1603 and 1503 because these regions have the most extreme of the fishery resource measure.

Marginal Values of Water as a Recreational Fishery Resource

Water's value as a recreational fishery resource is estimated by multiplying the day response to flow changes by the estimated values of a day of recreational fishing. We applied day value estimates derived by Hay and by Brown and Hay to our day response estimates (*4*,*9*) (table 4). Both Hay and Brown and Hay (who used the recently released 1985 FHWAR survey) estimated values by State using the FHWAR survey. The day value estimates for bass fishing (Hay) were between $7 and $14 and averaged $14.60. Those for trout fishing (Brown and Hay) were between $10 and $35 and averaged $17.88 (1989 dollars).

The estimated value of water as a recreational fishery resource varies across ASA's from 14 cents to values over $300 per acre-foot.[9] Values vary because of dif-

[8]The change in days fished estimated from the two-stage approach relies on the predictive power of P(fish) and (D|fish) because differentiating equation 2 with respect to FLOW, $\partial DAYS/\partial FLOW = \partial P(fish)/\partial FLOW * (D|fish) + \partial(D|fish)/\partial FLOW * P(fish)$.

[9]The estimated values in ASA 1503 likely exceed the actual values because the estimated marginal response is probably out of our model's forecast range.

Table 3—Change in days fishing per acre-foot change in streamflow. Drainage basins are listed by the Water Resources Council's Aggregated Subarea

ASA[1]	DAYS Acre-foot	ASA	DAYS Acre-foot	ASA	DAYS Acre-foot
101	0.029	0505	0.047	1202	0.375
102	.069	0506	.299	1203	.481
103	.667	0507	.132	1204	.874
104	.373	0601	.232	1205	.314
105	.119	0602	.096	1301	8.085
106	.025	0701	.709	1302	5.466
201	.466	0702	.324	1303	2.049
202	.289	0703	.240	1304	9.649
203	.502	0704	.106	1305	.439
204	.165	0705	.042	1401	3.994
205	.291	0801	.026	1402	3.836
206	.398	0802	.018	1403	3.583
301	.145	0803	.008	1501	8.770
302	.205	0901	.144	1502	3.539
303	.143	1001	.358	1503	150.229
304	.216	1002	.429	1601	.712
305	.410	1003	.373	1602	.338
306	.152	1004	.562	1603	26.189
307	.059	1005	.341	1604	.950
308	.052	1006	.238	1701	.056
309	.052	1007	4.788	1702	.021
401	.076	1008	.632	1703	.147
402	.184	1009	.194	1704	.035
403	2.365	1010	.889	1705	.011
404	.276	1011	.117	1706	.016
405	.283	1101	.108	1707	.036
406	.379	1102	10.648	1801	.111
407	.423	1103	.503	1802	.263
408	.101	1104	.161	1803	2.267
501	.269	1105	.672	1804	.981
502	.119	1106	1.534	1805	.655
503	.454	1107	.112	1806	10.456
504	.281	1201	.159	1807	1.747

[1]Aggregated subarea.

ferences in marginal responses to streamflow changes and because of variations in the day values of recreational fishing. In the more water-abundant Eastern States, marginal water values are usually less than $10 per acre-foot. In the dryer, more populated areas of the West, marginal water values are at their highest.

Water values are estimated for cold water and warm water recreational fishing, although an acre-foot change in flow is likely to partially affect both fisheries. The day value most applicable is, of course, an average of the cold water and warm water day values weighted according to the change in cold water and warm water days. This breakdown is beyond the scope of this analysis.

Our estimated water values are compared with water values estimated by Ward and by Johnson and Adams to look for consistencies in the estimated values and to delineate differences in approaches (*10*,*24*). Comparisons with these two studies are practical because these studies also compare current flow levels with natural flow.

Ward estimated the benefits of summer releases of water from upper reservoirs on the Rio Champ in northern New Mexico to increase the quality of the downstream fishery. He estimated demand for streamflow based on travel cost modeling and the change in visitation rates anglers said they would make on viewing pictures of different streamflow levels. The marginal value of an acre-foot of water for normal flow was estimated to be $29.57 (1989 dollars). Ward's region of study is the upper reaches of ASA 1302. The water leaving that study area continues through ASA 1302 improving the stream fisheries along the way until flowing into ASA 1303. The estimated marginal value of an acre-foot of water is $113.91 for bass and $64.26 for trout within ASA 1302. Our estimated water value should be higher than Ward's because it includes the fishery value of water while it is in Ward's

Table 4—Marginal values of an acre-foot of streamflow as a recreational fishery resource

ASA[1]	Bass[2]	Trout[3]	ASA	Bass	Trout	ASA	Bass	Trout
	Dollars/acre-foot			*Dollars/acre-foot*			*Dollars/acre-foot*	
101	0.59	0.29	0505	1.00	0.73	1202	10.48	10.18
102	.68	.56	0506	5.64	3.61	1203	13.44	13.05
103	9.46	6.78	0507	2.46	1.97	1204	24.42	23.71
104	5.95	3.40	0601	4.18	3.42	1205	8.76	8.51
105	1.51	1.09	0602	1.84	1.60	1301	221.20	158.31
106	.36	.25	0701	13.70	11.11	1302	171.15	119.84
201	7.31	4.86	0702	7.90	5.12	1303	57.24	55.58
202	4.70	3.05	0703	6.00	4.21	1304	325.34	175.80
203	8.80	5.19	0704	3.04	1.86	1305	12.26	11.90
204	2.60	1.53	0705	1.06	.69	1401	97.27	50.64
205	5.52	3.87	0801	.58	.42	1402	94.01	48.36
206	7.50	5.21	0802	.41	.30	1403	89.18	44.65
301	2.79	1.73	0803	.24	.14	1501	219.76	109.28
302	3.16	2.02	0901	2.07	2.24	1502	88.24	44.00
303	2.76	1.55	1001	6.49	5.56	1503	3780.85	1876.19
304	4.13	2.20	1002	7.22	6.52	1601	9.37	8.66
305	7.83	4.10	1003	6.64	5.76	1602	3.98	4.20
306	3.07	1.79	1004	11.37	8.81	1603	577.46	325.53
307	1.16	1.02	1005	4.97	3.92	1604	20.94	11.80
308	.97	1.15	1006	125.44	78.63	1701	.94	.68
309	.77	.89	1007	10.82	78.63	1702	.38	.27
401	1.35	.93	1008	10.82	9.72	1703	2.58	1.81
402	4.14	1.90	1009	4.38	3.29	1704	.63	.45
403	69.16	39.24	1010	14.41	15.90	1705	.19	.14
404	4.08	3.09	1011	2.28	1.77	1706	.38	.20
405	4.17	3.20	1101	8.25	10.28	1707	.42	.48
406	6.90	3.74	1102	202.10	159.30	1801	3.57	2.00
407	8.31	3.73	1103	8.25	10.28	1802	8.51	4.76
408	1.49	1.03	1104	2.88	3.20	1803	73.31	40.98
501	4.93	2.86	1105	16.15	13.45	1804	31.73	17.74
502	2.45	1.45	1106	34.23	37.96	1805	21.18	11.84
503	10.20	4.14	1107	2.31	2.38	1806	338.16	189.05
504	5.46	3.44	1201	4.46	4.26	1807	56.49	31.58

[1]Aggregated subarea.
[2]Based on net economic values by Hay (*9*).
[3]Based on net economic values by Brown and Hay (*4*).
[4]1989 dollars.

study area plus the value it generates when it continues downstream within ASA 1302.

Johnson and Adams estimated the benefits of water to steelhead trout fisheries in the John Day River Basin. A steelhead fishery production model was applied in conjunction with a contingent valuation model. The fisheries production model accounts for the time difference between a change in flow and the change in the quality of fishing. Our approach uses average flows to measure steady-state fishery productivity.[10] The John Day Basin lies in the central part of ASA 1702. Johnson and Adams estimated water values for spring, winter, and fall, making the comparison with our estimated annual value more difficult. Another difference is that their analysis only considered the benefits to the steelhead fishery where we included all fishery benefits. An acre-foot change in flow in ASA 1702 represents a change in flow in all areas of the drainage basin, not just in the John Day (unless all water in ASA 1702 originates in the John Day). So, the estimated benefits of an acre-foot of water in our analysis is an average of fishing benefits throughout the basin.

Nevertheless, John Day summer, winter, and fall water values were estimated at 59 cents, 5 cents, and minus 8 cents within the study area and $2.62, 20 cents, and minus 36 cents (1989 dollars) when downstream benefits were included. Our estimated value of an acre-foot of water in ASA 1702 is 19 cents and 13 cents within the basin and 38 cents and 28 cents when downstream values are included for bass and trout, respectively.

[10]As we pointed out earlier, low flow during years of below normal precipitation can result in increased catch rates for that year but lead to lower catch rates in the future as stocks are depleted and the productivity of the fishery falls.

The comparison of our results with those of Ward and of Johnson and Adams is very rough given the differences in approaches of these studies (*10*,*24*). However, the relative magnitudes of the estimated benefits are consistent across the two regions.

Marginal Response of Other Variables

Despite the differences in assumptions behind the two models, marginal responses are consistent, with some exceptions. Marginal effects based on the two-stage approach are very close to those based on the single-stage approach for URBAN, SEAMILES, STREAM, and FLOW. Some difference exists in the estimated effect of the individual's gender (SEX). Their difference, however, is less than 40 percent of the single-stage estimate. Both approaches indicate that an increase in INCOME increases days fished at lower income levels and decreases days fished at higher income levels. But, the two-stage results suggest that negative effects of increased income occur at a lower level of income. The difference in marginal responses to lake resources is likely due to the lack of significance of LAKEIN in (D|fish).

Conclusions

Examined within a household production framework, the level of streamflow is highly significant as an input in the production of the recreational fishing commodity. The estimated effect from a change in streamflow is consistent across the single-stage and two-stage estimation procedures.

The total downstream change in fishing associated with an acre-foot change in streamflow varies across the United States due to variations in resource availability and variations in the number of people affected. There is less than half a day change for 69 of the 99 ASA's. The more water-abundant Eastern States tend to have the lower marginal responses despite the higher population densities.

The variations in impact of water depletion can provide policymakers with an indication of regional variations in the importance of water in recreation. Water values in recreational fishing allow comparisons of water values in alternative uses. Based on fishing day values estimated in earlier studies, the value of water as a fishery resource is estimated. These values vary across ASA's but usually fall between $10 and $35 per acre-foot. The estimated values can be compared with consumptive values of water to aid in water allocation decisions.

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Is Agricultural Productivity Research Productive?

Agricultural Productivity: Measurement and Explanation. *Edited by Susan M. Capalbo and John M. Antle, Washington, DC; Resources for the Future, 1988, 404 pages, $30.*

Reviewed by Roger K. Conway

Why has productivity growth followed a certain path? How does policy affect productivity, and can we project future growth rates based on policy? The research record in answering these questions sounds an uncertain trumpet and this volume echoes the refrain.

This volume's strength: it is a capable survey and a collection of papers on the state of knowledge of agricultural productivity and production accumulated during the 1970's and early 1980's. Most of these papers were derived from a 1984 Resources for the Future workshop on agricultural productivity. The opening section reviews new methodological developments in production theory and multifactor productivity measurement and summarizes the empirical evidence on agricultural productivity and production. I would like to have seen a more searching critique of the literature. For example, there are problems with econometric estimation procedures used to derive productivity measures. A close conceptual relationship exists between index number measurement of multifactor productivity and econometric estimation of certain production functions. However, an important difference separates the two. Index number measurement is deterministic and the econometrics is statistical. Harper and Gullickson (1986) cited the possibility of wide differences between the two because of the properties of the error term.[1] Since the theory itself is developed deterministically, it is unclear whether the theoretical mathematical conditions are met in a stochastic framework.

Events have muted Richard Shumway's generally on-the-mark critique of the current Laspeyres ERS productivity series. ERS held a productivity conference in spring 1988 to unveil the new Tornqvist quality-adjusted indices developed by Ball (1985) as the forthcoming official ERS indices. Ball's work addresses the recommendations suggested by Shumway as well as the 1980 AAEA task force report for improving the ERS productivity measures.

While the Capalbo productivity data set (page 106) has been used a great deal recently for empirical research, it has serious limitations. Capalbo fails to include inventories in the data, even though they are an important component of agricultural capital assets. Gollop and Jorgenson are cited as the source of the labor data, yet that data set covered only the period 1948-78. How were the labor data extended to 1983? And, capital service prices are computed as the sum of opportunity costs plus depreciation and taxes. Laurets Christensen (1971) defines opportunity cost as property income less capital gains. Capalbo ignores the capital gains component. Capalbo used crop year gross production and season average prices instead of calendar year marketing and cash receipts. Ball's data set does not suffer from these limitations.

New measurement techniques not discussed in this volume have great importance. For example, failure to take account of variations in capacity utilization in agriculture can distort productivity measurement. Preliminary work by Hauver, Yee, and Ball (1990), which adjusts for capacity utilization, is underway.

Another new approach to solve the almost intractable aggregation measurement problem is to use hedonic procedures and to redefine the production function in characteristics space as suggested by Triplett (1985). A technological advance would then be indicated by the availability of different combinations of characteristics rather than input levels.

The rest of the book explores empirical measures of productivity and seeks to isolate sources of growth. Papers by Hazilla and Kopp and Huffman both stress the need for more disaggregate measures in order to improve investigations of sources of growth, farm behavior, and the distributional effects of farm policy. Mundlak's paper is very useful because he adjusts for aggregation by constructing an aggregate production function with stochastic coefficients from micro-units. His approach endogenizes technical change, offering an attractive alternative to the simple addition of a time trend in empirical work. Antle, a gifted researcher, continues his important work of presenting the agricultural production process in a dynamic framework.

These papers, however, are limited by their unquestioned adherence to neoclassical theory. The assumption that farmers know all efficient input combinations, whether or not they have been tried, is somewhat unrealistic. Neither is there any room for entrepreneurial innovation in the neoclassical production process. Farmers are free to pick among all known technical possibilities to produce their output

Conway is a section leader with the Resources and Technology Division, ERS.

[1]Sources are listed in the References section at the end of this review.

under profit-maximization and certainty. We know that the farmer's response to risk permeates production decisions, yet we ignore this behavior in productivity measurement research. Entrepreneurial rents are swept under the rug in accounting procedures by assuming perfect competition and complete information.

Another important issue not directly addressed by this volume is that input decisions in agriculture must often be made with explicit consideration of flexibility versus efficiency trade-offs. The expense of flexibility is usually a loss in economic efficiency relative to a best practice for a specific static operating environment. Therefore, the farmer's calculation of the flexibility-efficiency margin is an important element in an evaluation of a farmer's technological possibilities and behavior. So, the role of risk and/or uncertainty plays an important part in choosing durable inputs, since dynamic efficiency must be achieved in a context of flexible technologies. For example, irrigation technology may be efficient *ex ante* but inefficient *ex post* if there is sufficient rain in a given year, so to maintain flexibility when the weather is dry, farmers may invest in irrigation equipment.

The book recognizes that agricultural policies have considerable influence on productivity measurement and sources of growth, but little here is useful to the policymaker. Perhaps understandably, none of the papers really deals with the measurement problems caused by farm policy. Output and input market prices are not competitive because of farm policies. The allocation of inputs is altered when farmers act on Government support prices rather than competitive prices. Expectations of farm policy changes surely influence a farmer's input decisions and, consequently, productivity growth.

Indeed, farmer expectations, in general, should be explicitly accounted for by distinguishing between *ex post* and *ex ante* measures of output and productivity. *Ex post* measures of output and productivity represent what actually occurred and show the effects of unanticipated shocks to the agricultural production sector, such as weather and the influence of agricultural and macroeconomic policy. *Ex ante* measures consider what the farmer anticipates the economic environment to be in the decisionmaking process. *Ex post* and *ex ante* measures are likely to differ. When they do, economists may mistake farm behavior and expectations for scale change and technical efficiencies.

Monetary policy clearly plays an important role in determining agricultural productivity growth rates unacknowledged by this volume. New technologies frequently require that increased purchases of nontraditional inputs and credit arrangements become important as a result. Lee and Chambers (1986) found that relaxing expenditure constraints would lead to greater capital and labor usage, less land usage, and probably larger labor productivity increases.

Promising new research may shortly address the farm policy issue. A recent paper by Swamy, Lupo, and Sneed (1989) uses a stochastic coefficients regression approach that allows the elasticity of output with respect to each input to depend on a random variable and deterministic variables, such as farm policy levers, scale of operations, and research and development expenditures. This procedure solves the Solow-Stigler controversy under certain conditions by allowing effects on changes in technology and economics of scale to be separated. The approach also allows relaxation of competitive assumptions, estimation of total factor productivity directly from nontime trend regression coefficients, and forecasting outside the sample. Farm and technology policy simulations on agricultural productivity would also be possible.

Capalbo and Antle's compilation, then, is a bit of a curate's egg. Readers new to the literature will find a cogent, albeit uncritical, summary of production theory and measurement issues. Others seeking the latest developments in the literature and desiring a strong linkage between productivity growth and policy must ferret out individual papers or await a future volume.

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Can Economics Be Used To Manage "Our" Forests (or does Smokey the Bear need to learn about multi-product cost functions)?

Multiple Use Management: The Economics of Public Forestland. *By Michael D. Bowes and John V. Krutilla. Washington, DC: Resources for the Future, 1989, 356 pages, $40.*

Reviewed by Daniel M. Hellerstein

Whether seen on television news or in the comments appendix to a USDA Forest Service forest plan, the debate concerning the future of public forestlands is rarely trivial. Conflicts as obvious as the choice between wilderness preservation and guaranteeing the supply of timber products, or as subtle as the tradeoff between old growth forest and enhanced streamflow, must be dealt with by the forest manager.

Into this public debate, Michael Bowes and John Krutilla submit their book with the intention to:

> ... bring to the economic analysis of multiple-use management of public forestlands an updated theoretical framework and an illustration of its applicability to the management of public forestlands.

Given their stated goals, they succeed in producing a wide-ranging synopsis of current knowledge. The breadth of material does not break new ground but will bring insight to most resource economists. For readers with more general training, the depth and clarity of presentation unite to provide a good introduction to the topic of multiple-use management. Perhaps, unavoidably, the trained natural resource economist may cry for greater rigor, while those with less economic training may become lost in formulae.

The book starts with a concise history of public forestland management in the United States, followed by an overview of current outputs and management directions on Forest Service lands. Here, the underlying theme of the importance of the wide range of outputs is introduced. It is well recognized that the combination of poor timber productivity, spectacular scenic beauty, and ecological integrity in many of the national forests often dictates against a market-commodities emphasis. In other words, the values of timber, minerals, and forage are often below the value of nonmarket commodities, such as outdoor recreation, wilderness preservation, enhanced streamflow, and wildlife protection. The trick is where and when to manage for these sometimes exclusive, but sometimes complementary, beneficial products.

As a first cut at the problem of multiple outputs, the book presents a variety of single-period models of forestland production. The key problems are how to represent the many interrelationships between the various outputs, and how to use such a representation to maximize the flow of benefits from the land. Bowes and Krutilla focus on cost functions as a tool for management, as does much of the modern literature on production economics.

The cost function approach has many advantages. Key concepts, such as the complementarity (jointness) or substitutability (nonjointness) of the production of various outputs, are readily expressed in terms of the cost function. For example, if isocost curves for two goods, say timber and wildlife, can be shown to be convex to the origin, then production should be specialized; one should not attempt to produce both items on all land units. Conversely, the combination of diseconomies of scale and complementarity may create situations where the production of one good increases the availability of other goods, for example, as when a limited timber harvest enhances wildlife habitat. Again, the cost function can be used to show just what mix is optimal.

An especially useful aspect of the cost function approach is the concept of separable costs, which is defined as the cost of producing some level of a single output while holding all other outputs constant. Separable costs are key to correct analysis of a variety of policy debates. In particular, the case of below-cost timber sales can be identified as one of separable costs.

Bowes and Krutilla adequately present the somewhat imposing theory of joint production in the context of forestlands. Readers without formal training in production economics, however, will need to study these models carefully. The problem of a disparate audience is never easily solved, although a theoretical appendix would be appreciated by this reviewer.

The chapter on dynamic models, in expanding on these single-period models, is the heart of the book. Building on Bowes' work at Resources for the Future, the authors address intertemporal management of a geographically diverse forest. They start with

Hellerstein is an economist with the Resources and Technology Division, ERS.

Faustmann-type models, which are based on the timber value of a single stand, followed by a discussion of the Hartmann method of incorporating stand-age dependent amenity values into single-stand models. An amenity value is a measure of the benefit of a nonmarket commodity, for example, the value of a scenic trail to hikers.

Although single-stand models can illuminate the comparative statics of rotation length and the resulting harvest cycles, the authors argue that focusing on single stands is a poor approximation to the real world. Basically, a forest is more than a collection of independent stands. In other words, a single clearcut can ruin a beautiful view. Or, a single clearcut can create a valuable edge-effect habitat for a decade. Complicating this dichotomy are the changes in the effect of a clearcut with the aging of the surrounding forest. Add a number of other management options, and you approach the forest management problem.

The authors tackle this problem with a multiple-stand, dynamic management model. Besides the traditional timber yield function, they introduce an amenity function which yields amenity values (for nonmarket commodities) that are dependent on the particular state of the surrounding forest. The concept of asset value (the "sale" price of the land) is used to facilitate presentation and exploration of the features of their model. We find that the introduction of multiple sites can greatly affect the time pattern of management, and harvest rules can become very complex.

My comments concerning the authors' multiple-output, single-stand models of forest management also apply to their multiple-stand models, that is, it's a tough problem, the authors provide an adequate introduction, but a supporting technical appendix would be useful.

The second half of the book consists of several case studies, a critique of the budgeting process of the Forest Service, and a discussion of methodologies for valuing recreational quality. Although the case studies are meant as applications of the theoretical models, the authors make the usual compromises with data unavailability and computational complexity. For example, amenity functions are simply unavailable, and they must use very rough approximations.

In a sense, the authors reveal their preference for theoretical research by first presenting the theoretical models, then approximating the models when it comes time to attend to the real world. The applications-oriented reader may prefer to see what is reasonably done, supported by the hypothetical discussion of what could be done. The book would benefit from a more careful linkage between the theoretical and applied models.

A substantial portion of the benefits of national forestland is recreation use. These lands vary greatly in characteristics that recreationists value, such as hiking opportunities. Given an ability to modify the landscape, such as by building new trails, there may be considerable opportunity for land managers to increase social welfare. Therefore, methods for valuing recreational "quality," not just the total quantity of recreational trips, are needed.

The authors are to be commended for their attention to this issue of recreational quality. Although their view is somewhat idiosyncratic, they generally succeed in placing a variety of valuation techniques in a broad theoretical framework. They review both simple travel cost models and several hedonic techniques. The reader should be warned that this is not a solved problem, and that the differences among models can be subtle. My muted praise stems from the authors' haziness, despite their concerted efforts, in explaining the behavioral and statistical differences among these models. For example, their net hedonic model may be best described as a total expenditures model, in contrast to their gross hedonic model that is best described as an endogenous trip-quantity model. In addition, the focus on quality valuation precludes discussion of recent advances in quantity-oriented measures of total site value.

Bowes and Krutilla have produced a well-written overview of the tools available to economists interested in managing public forestlands. The applied and theoretical analysis combine a sophistication of technique with an understanding of the breadth of the issues that are essential to improving Forest Service policies. Perhaps, their greatest contribution is to re-enforce the importance of interactions: from the joint aspects of production on a single site, to the prevalence of cross-site affects that, in turn, induces complicated intertemporal dynamics. Although other critics might prefer a more poignant critique of current Forest Service policy, I recommend this book to a wide readership, with the proviso that some might be frustrated by unfamiliar economics, while some may thirst for more theoretical rigor.

Perestroika Reaches the American West

Markets for Federal Water: Subsidies, Property Rights, and the Bureau of Reclamation. *By Richard W. Wahl. Washington, DC: Resources for the Future, November 1989, 308 pages, $30.*

Reviewed by Michael R. Moore

Look at a map of the United States: large territories of land define the 17 Western States of the 48 coterminous States. To many scholars of the arid West, however, large volumes of water must coexist with the land to define a Western State fully and accurately. A certain volume of water, in addition to land, is essential to a State's integrity and economic viability, they argue. Water is different from other fungible commodities and should not be transferred privately without regulations that protect the water endowments of communities, river basins, and States.

To free-market resource economists, the water-is-different attitude dooms the West to waste precious water resources. Water is not essential to a State's territorial integrity, they maintain, and property rights in water should be exchanged freely like coal, computers, and corporations. These economists claim that the Bureau of Reclamation (the Federal agency that planned, implemented, and operates a large share of western river development) has violated economic principles of rational resource development and currently impedes water transfers that would contribute to economic growth in the West. In their view, reclamation water rights should be made unambiguously private and the Bureau of Reclamation should be abolished.

Richard Wahl's *Markets for Federal Water* chronicles the Federal subsidy policy of irrigation water supply, documents the impediments to market exchanges of reclamation water that emanate from reclamation law and policy, prescribes the market approach to reallocating reclamation water, and develops several case studies illustrating how water markets could solve problems faced by the Bureau of Reclamation. *Markets for Federal Water* does not argue dogmatically for completely deregulated water markets and an end to the Bureau of Reclamation. Instead, Wahl maps out a simple blueprint of *perestroika* for western water institutions: reduce the Federal Government's role in water allocation and management, and permit individuals, irrigation districts, cities, and States to act creatively by solving water supply problems with water markets. As the Bureau of Reclamation adopts an objective of water management to replace its resource development mission, Wahl's blueprint offers a reasonable, almost inevitable, reform of Federal policy concerning the reclamation program.

The book functions at several levels of discourse: (1) as Federal water policy journalism, with a historical account of the reclamation subsidy policy that updates the reader to events in the 1980's; (2) as political economy, with a view of the Bureau of Reclamation as an agency "captured" by its clientele; (3) as a rhetorical essay, with the purpose of influencing policy and attitude in the Bureau of Reclamation and the U.S. Congress; and (4) as economic and legal analysis, with a reliance on economic principles of efficiency, property rights, and market incentives as a way of organizing a blueprint for institutional reform. This variety is an achievement in itself and serves to make the book interesting and, frequently, lively. Prospective readers take heed though: the book is varied and contains pockets of information found in other sources. Readers with diverse backgrounds—economists, policymakers, natural resource managers, lawyers, westerners—with an interest in western water issues, in general, or the Bureau of Reclamation, in particular, will want to read the entire book. The book's introduction provides a helpful outline to guide the more specialized consumer.

Part I reviews the history of the Federal subsidy policy of western river development and calculates the subsidy levels implicit in the policy. Worster's *Rivers of Empire* (1985) documented the origins of the reclamation program in more detail, while Burness and others (1980) preceded Wahl in describing the evolution of the subsidy policy through 1980. This portion of Part I remains essential, though, to form a coherent whole. Based on recent events concerning California's Central Valley Project and the implementation of the Reclamation Reform Act of 1982 (RRA), Wahl gives new information on reclamation policy in the 1980's. Here, the book documents the captured agency thesis in the case of the Central Valley Project (p. 65):

> The history of the Central Valley Project and water rate-setting reveals that the federal subsidy for irrigation has been significantly increased through administrative means. Whereas the interest-free subsidy embodied in Reclamation law amounts to $2.20 billion-$2.48 billion of the project's $3.77 billion cost (in 1986 dollars), administrative measures will increase the subsidy to about $3.56 billion.

Moore is a resource economist with the Resources and Technology Division, ERS. He thanks Mark Kramer for helpful discussions on the topic of the Bureau of Reclamation.

The extensive reporting on the RRA, the most important piece of reclamation law in decades, is welcome. The background leading up to the RRA makes fascinating reading. The 160-acre limitation, a provision of the original Reclamation Act of 1902 intended to promote the family farm, was not enforced in California. A land reform movement, National Land for People, sought to use the provision to force large landowners to sell blocks of land with reclamation water supplies at below-market prices. The RRA represents a legislative attempt to define an enforceable acreage limitation. Declaring that the details of RRA implementation remain to be determined, Wahl writes (p. 105):

> During these eight decades, the affected water users have been successful in securing administrative, legislative, and judicial actions that in one way or another either exempt some categories of project lands from application of acreage limitation or expand the acreage entitlement, thereby protecting the property and financial interests of larger farming operations.

By the end of Part I, Wahl has substantiated the transformation of reclamation politics from a program supported by a goal of western settlement to a program supported by the sheer political power of its clientele. In the transformation process from goal-oriented policy to distributive politics, the subsidy policy changes from being open, legislative, and defensible to hidden, administrative, and controversial.

The book makes a major transition in Part II from study of the water supply subsidy policy to analysis of marketing of reclamation water. Attention focuses on water use efficiency as the overriding concern. Wahl concludes quickly that marketing is the only effective and politically acceptable policy alternative to promote efficiency. Among other alternatives, water conservation requirements are a blunt, inefficient option, and water price increases are not politically viable given the proven political power of irrigation interests. The book continues with detailed new information on impediments to water transfers created by Federal reclamation law, policy, and administrative practices. This is a rich, valuable source for the reader who relishes detail. Among the interesting facts is this: reclamation contracts, which state the terms between the Federal Government and individual irrigation districts (numbering roughly 600), contain substantial variety in the restrictions and stipulations agreed to by the parties. Thus, in addition to impediments contained in general reclamation law and policy, individual contracts frequently would need to be altered to accommodate water marketing.

The four case studies comprising Part III present somewhat familiar analyses of how water transfers could solve major problems of water supply and water quality. The familiarity occurs because much of the existing economic analysis of western water allocation uses a similar case study format. The opportunity to solve water quality problems at Kesterson National Wildlife Refuge and at the U.S.-Mexico border on the Colorado River, though, adds a dimension to the range of problems that become tractable with water marketing.

In addition to providing solid economic analysis, the case studies contribute to the book's rhetorical impact. The evidence begins to cohere: Federal water policy must permit water transfers for the West to adapt to different economic, political, and environmental circumstances. On this score, *Markets for Federal Water* contains its own best tribute: an appendix containing a verbatim transcript of the Department of the Interior's "Principles Governing Voluntary Water Transactions." Adopted in December 1988, the principles direct the Bureau of Reclamation to facilitate water marketing. Wahl (who has been employed by the Department of the Interior for the past decade) and, I assume, other people deserve recognition for their efforts at policy reform of the Bureau of Reclamation.

Although the book is instructive in defining the accurate calculation of water subsidies, it fails to address directly a myth associated with reclamation water prices. The reclamation subsidy repayment myth states that "if the Federal Government would price water at a rate to recoup the original capital investment in a project, then the water would be used efficiently." On existing reclamation projects, however, capital investments in dams, reservoirs, and canals represent fixed and sunk costs, so the investment costs do not vary with the level of water production and are not eliminated if production ceases. Capital investments with this cost structure "are no longer a portion of the opportunity cost of production," write Baumol, Panzar, and Willig (1982). Repayment of the original reclamation investment, consequently, is irrelevant to the allocative efficiency implications of current water pricing practices.

The reclamation subsidy repayment myth is a misconception that often influences debate on the reclamation program. For instance, the "full cost" pricing provision of the RRA, a pricing reform designed to recapture the reclamation subsidy, represents this attitude (see pp. 84-85 and 128). While historical investment costs associated with the reclamation program may be associated with current political or fairness issues, economists should point out that pricing policies to recapture the past reclamation subsidy are not based on an economic concept of costs.

Finally, as a model for reform of the reclamation program, are less regulated water markets sufficient?

Perhaps the question is unfair, as Wahl never claims to write the final word on reclamation reform. The book presents such a strong rhetorical argument for markets, though, that it must be viewed as a full blueprint. By this standard, it falls short in several respects.

First, given the history of subsidy, why should the Government support additional opportunities for irrigators to reap the windfall profits that deregulation would create? Wahl submits that, through political power and a captured agency, irrigators will block other reforms. If this is true, then the RRA, arguably, never would have become law. Western water politics may have changed enough to make policies other than deregulated markets feasible.

Second, will sole reliance on market activity result in efficient water allocation? Certainly many opportunities exist for mutual financial gain between irrigation districts and cities. But numerous river and water uses are nonconsumptive with traits of pure public goods. (Inhabitants of Colorado's Western Slope prefer that Colorado River water go to Los Angeles rather than across the Continental Divide to Denver because "at least we get to watch the water flow by on its way to Los Angeles.") The book's major premise that market outcomes achieve efficiency does not necessarily hold. Allocative efficiency of river and water remains an important research issue with substantive policy and program implications. For instance, Federal management or regulation of rivers as environmental and recreational assets may be as important to economic efficiency as their management for irrigation water.

Third, Native American claims to western surface water have been seen as legitimate, large, and unsatisfied. On legal and moral grounds, the Federal Government may incorporate this aspect of water allocation into a blueprint of Federal water management. For these three reasons, market activity should be only one of several policy instruments in the post-dam-building era. A full blueprint for an appropriate Federal role in the wise and active management of western rivers—a mission based on river and water stewardship rather than simply water management—remains to be articulated.

The preceding shortcomings, though important, fall largely into the category of errors of omission rather than commission. In the realm of domestic natural resource issues, reform of western water institutions promises to be among the most important and controversial of the next two decades. *Markets for Federal Water* easily stands as one of the few important contributions to the topic.

Recommended Related Reading

Baumol, William J., John C. Panzar, and Robert D. Willig. *Contestable Markets and the Theory of Industrial Structure*. New York: Harcourt Brace Jovanovich, Inc., 1982.

Burness, H. Stuart, Ronald G. Cummings, William D. Gorman, and Robert R. Lansford. "United States Reclamation Policy and Indian Water Rights," *Natural Resources Journal*, Vol. 20, 1980, pp. 807-26.

Frederick, Kenneth D. (ed.). *Scarce Water and Institutional Change*. Washington, DC: Resources for the Future, 1986.

Hamilton, Joel R., Norman K. Whittlesey, and Philip Halverson, "Interruptible Water Markets in the Pacific Northwest," *American Journal of Agricultural Economics*. Vol. 71, 1989, pp. 63-75.

Howitt, Richard E., Dean E. Mann, and Henry J. Vaux, Jr. "The Economics of Water Allocation," *Competition for California Water*. (Ernest A. Engelbert and Ann Foley Scheuring, eds.) Berkeley: University of California Press, 1982.

Worster, Donald. *Rivers of Empire: Water, Aridity, and the Growth of the American West*. New York: Pantheon Books, 1986.

Foreign Aid and Its Effectiveness

Aid and Development. *By Anne O. Krueger, Constantine Michalopoulos, and Vernon W. Ruttan. Baltimore: The Johns Hopkins University Press, 1990, 386 pages, $45.*

Reviewed by Gene Mathia

How should foreign assistance be used to stimulate the economies of developing countries? Read this book and find out. The authors are seasoned observers and analysts of foreign assistance programs, capable of providing the useful insights necessary to assess aid policy.

The authors' goal is to find out how and why aid programs and projects succeed or fail. They concluded that "aid effectiveness needs to be measured in terms of results, that is, its contribution to stimulating economic growth and improving the welfare of the recipient." The authors used estimates of economic rates of return to resource transfers to draw conclusions about the success of projects and/or programs. Noneconomic and donor objectives were not incorporated into the evaluation criteria, but if the security and political dimensions had been considered, the case for bilateral foreign assistance (a principal donor giving to a single recipient) to developing countries would have been greatly strengthened.

The book first provides a brief history of foreign assistance, starting with the Marshall Plan of the 1940's. The book's description of the maturation process for foreign assistance since then is an interesting example of learning by doing. Highlighted are how the first efforts directed large capital resource transfers to Western Europe for infrastructure. Government officials had assumed that the lack of capital limited development, probably a valid assumption considering the war damage in Western Europe. Development has since evolved to place more emphasis on human resource restraints to growth, requiring technical assistance, health, and education. The focus recently has been on supporting institutional development and removing policy constraints which often require complex and often painful policy reforms. The examples in the book draw heavily on projects and programs in the agricultural sector.

The case studies and anecdotal materials draw heavily from the bilateral experience of the United States as the principal donor to a single recipient but also provide the reader with the objectives, procedures, and problems of multilateral assistance. Multilateral assistance refers to the pooling of resources of several donors with joint or committee decisionmaking. The argument that holds throughout the book is that multilateral aid is more effective than bilateral aid because it is more directly based on recipient development interests, is better coordinated, and removes specific donor objectives from the allocation and management processes.

The chapter on "Donor Policies, Donor Interests and Aid Effectiveness" explores donor motivations (economic, political, humanitarian, security, and even commercial interests) for aiding developing countries. Discussed are the tools used to accomplish national goals and how important the achievement of these national goals may be in mustering political support for foreign aid resources. Although donor considerations are recognized, the evaluation process did not explicitly include the costs/benefits of donors in the success equation. In fact, in evaluating both project and program aid about donor self-interests, the tone was: "Pursuit of nondevelopment objectives—whether political, cultural, or commercial—through economic aid can potentially have a seriously detrimental impact on aid effectiveness by affecting (a) the country allocation of the aid or (b) given the country allocation, how effectively the aid is used." The implication is that if donor assistance were viewed by the donor as truly humanitarian and by the recipient as developmental, many past aid efforts would have scored much higher.

An alternative approach might have been to include multi-objective, multi-participant goals in the evaluation criteria that measure the success of aid efforts. The single-objective approach fails to quantify the long-term effects on factor productivity, which extend far beyond the period usually used to measure economic costs and benefits. Of particular concern is the omission of the demonstration effects associated with aid, which are potentially important in changing traditional attitudes and processes.

A key theme throughout the book is that aid benefits reach full potential only when recipient governments undergo certain policy reforms. An economy grounded in a free market and an export-oriented, private enterprise framework is the ideal development model. Many times, donors failed in their efforts to influence the recipient government to accept policies designed to improve the economic environment. Some recommendations included removing input- and output-distorting interventions, getting the macroeconomic and trade policies right, and providing for strong physical, institutional, and human infrastructure. The obvious conclusion is that donors should condition aid on necessary changes in the economic environment. Several examples, however, were cited where donor pressures for

Mathia is an economist with the Agriculture and Trade Analysis Division, ERS.

needed change were counterproductive. The evidence seems to support the argument that aid works best in an economic climate that features minimum government intervention but a strong government with progressive development strategies.

Most reviewers of foreign assistance attempt to assess aid's effects in both India and South Korea, two countries that provide an interesting contrast in national and trade policy approaches and economic environments. India has maintained an inward-looking industrialization strategy requiring much public involvement and a developing agricultural sector. South Korea adopted an outward-looking industrial strategy which depends on private entrepreneurship and virtually ignores agricultural growth beyond domestic needs. Aid for India was credited with changing attitudes and developing a productive national agricultural research system. Aid for South Korea likely led the Korean Government to carry out the reforms that boosted its industry into international competition.

The comparison of development paths of Ghana and the Ivory Coast demonstrates how important the political setting is to the success of external efforts and how fragile apparent development success may be over time. Aid has been credited with enabling Ghana to experiment with socialism and state control as growth stagnated. The Ivory Coast, while starting far behind Ghana at the time of independence, used aid to promote foreign trade, investment, and financial flows.

Turkey's situation illustrates how security concerns and strategic geographic location may dominate economic development interest. For example, aid may be provided to maintain political stability as its primary objective while the economic objective is secondary. It is likely that similar political considerations would dominate the aid packages for the four or five largest current recipients of U.S. aid. The book would have been improved by including case studies on Israel, Egypt, Pakistan, or the Philippines, recipients of U.S. foreign assistance where donor political and security interests strongly affect the level of aid, but where the donor can exert little influence over economic and trade policies. Such studies could point up possible weaknesses in using only economic costs and returns as the measure of effectiveness.

The concluding chapter is a summary of the assessments of past aid efforts. It recognizes the difficulties in measuring the effects of assistance packages as being: (1) the complex and frequently conflicting economic and political objectives, (2) aid that is generally too small compared with national GNP to exert measurable effects, and (3) aid that is usually provided to countries with critical development problems and weak institutional infrastructure. A generally positive assessment of foreign assistance, however, is presented along with continued support for aid under a variety of aid packaging. Programs directed at hunger, health, and education have scored relatively well. Agricultural research aid has scored consistently high. Both program and projected aid are helpful, but the success rates are even better when the aid is untied from the direct donor interests and is supported by economic and political reforms.

The Economics of Meat Demand. *Edited by Reuben C. Buse. Proceedings of the Conference on The Economics of Meat Demand, October 20-21, 1986, Charleston, South Carolina, 375 pages, free.*

Reviewed by Wayne D. Purcell

"To identify what economists know about the demand for red meat and the implications of this knowledge." Reuben Buse and Richard Haidacher introduce the book with this, the objective of the Conference on Economics of Meat Demand. What the book does is lay the groundwork for a very important and continuing need—to get some of the conflicts between conceptual and analytical dimensions of "demand analysis" resolved.

Haidacher elaborates on the objectives of the symposium. He suggests the central issue of the session is the perceived inability to obtain an adequate explanation for the observed changes in per capita consumption of meat products. Buse follows with an excellent graphical presentation of changes in consumption patterns. Buse notes that per capita consumption of all foods has changed very little since 1960, but he documents a major change in broad food categories. Starting in the early to mid-1970's, per capita consumption of plant products increased rapidly compared with per capita consumption of animal products. This diverging pattern is presumably what Haidacher had suggested we cannot adequately explain. Buse examines price relationships across various foods, expenditures, elasticities, and various other economic and non-economic factors that could influence meat consumption. He suggests that the data show convenience to be an increasingly important attribute for consumers, but notes that we do not have model specifications to show the importance of convenience.

Ronald Schrimper identifies sources of cross-sectional data for demand analysis and discusses data-related issues such as aggregation and the inevitable time lag between the time the data are collected and when they are available for analysis. David Smallwood, Haidacher, and James Blaylock provide a review of the research literature on meat demand. Especially useful are their tables showing estimates of elasticity parameters by author and summarizing the results of studies on structural change in retail meat demand. The authors note the inconsistency in the conclusions across studies, and express concern about the frequent conclusion that unexplained changes are due to the "tastes and preferences demand shifter." They note that relying on a "demand shifter" that cannot be included in the model leaves us incapable of distinguishing between structural change and model specification error.

Jean-Paul Chavas discusses the issues involved in testing for structural change in meats. Especially important in Chavas' discussion of why structural change is important. He notes that if structural change has occurred in the red meat sector, then the entire sector must attempt to deal with and adjust to the changes if the economic viability of the sector is to be insured.

Section 2 offers several studies that deal with price and income effects on changes in meat consumption. Kuo Huang and Haidacher provide the results of an analysis which involved estimation of a complete food demand system. They conclude that changes in price and incomes were overwhelmingly responsible for changes in (red meat) consumption during 1953-83. Walter Thurman differs with the Huang-Haidacher conclusions. He follows with a report on a separate analysis of the 1955-83 period, concluding that it is reasonable to attribute a significant amount of the change in meat consumption to factors other than meat prices and incomes.

Michael Wohlgenant analyzed the possible increased sensitivity of beef demand to changes in poultry prices as we increase the proportion of beef consumed as ground beef. He concludes that the composition of beef consumption is significantly affected by changes in the poultry market.

Roger Dahlgren reports how he employed the Rotterdam Demand Model popularized by Theil to examine whether U.S. meat demand is in equilibrium. He used annual data for 1950-85. Dahlgren concludes that in the mid-1980's, the demand for meat was "back in equilibrium." He views the 1970's as an aberration caused by unusual shocks (such as price ceilings and an energy crisis).

S.R. Johnson reviewed the efforts by Huang and Haidacher, Thurman, Dahlgren, and Wohlgenant. He discusses the development of modeling technique and the implications of the restrictive assumptions that must be employed in approaches such as the Rotterdam model. Johnson is positive about the Huang-Haidacher effort, and refers to it as evidence that economists can explain observed developments in consumption patterns. This conclusion comes in spite of earlier expressed concerns about the Huang-Haidacher methodology. Johnson correctly notes that the functional form employed in efforts such as those

Purcell is professor, Department of Agricultural Economics, Virginia Tech, Blacksburg.

by Huang and Haidacher must be an approximation of the true market demand structure. He then refers to the Huang-Haidacher effort, which showed an R^2 around 95, and concludes that with an R^2 that high, the model was apparently the correct specification.

Johnson's conclusions could be criticized. Time-series data involving per capita consumption, and such variables as price and income, make it next to impossible to get a low R^2 in almost any functional form one chooses. Using the observed R^2 and 95 to support the implicit argument that the model truly represents the "real world" appears to avoid some rather obvious issues and appears to be an explicit example of what could be labeled inconsistency between the underlying conceptual framework and our modeling efforts.

Section 3 of the book looks at the effects of demographics and changes in the demographic profile as a reason for change in meat consumption. Thomas Cox, Reuben Buse, and Antonio Alvarez examine at-home consumption. The authors find that the parameters of at-home protein demand changed between 1972-73 and 1980-81. If this assessment is correct, the authors indicate (1) using time-series data for demand analysis probably misses longer run sources of change, and (2) using cross-sectional data sets more than a few years old may be misleading.

Examination of the effects of demographics is continued in separate efforts by Jong-Ying Lee, Vicki McCracken, and Oral Capps, Jr. Of interest among Lee's findings is that consumption of red meat at home and expenditures on red meat are negatively related to college education of the female head of the household. McCracken found that income and the value of the time of the person who was the food manager in the household were positively related to eating away from home. Capps concluded that added convenience will be important in efforts to increase at-home consumption of meats. For various beef cuts, Capps' analysis indicates that expenditures on convenience meats, such as ready-to-cook, precooked, and microwavable products, are likely to rise 1.5 times faster than those on less convenient steak or roast cuts.

Ben Senauer reviews the efforts by Cox-Buse-Alvarez, Lee, McCracken, and Capps. He sees the Capps and McCracken efforts as complementary. McCracken's findings that show income elasticity, for example, is much higher for higher income levels are consistent with Capps' results that show some increased demand for convenience in the higher income households. Lee's results are also judged to be consistent with the Capps effort. Senauer then turns to a discussion of the Cox-Buse-Alvarez paper, reemphasizing the dramatic impact of demographic factors on food consumption patterns. He concurs with the authors' assessment that the significant implications of the demographic forces raises questions about the routine use of time-series data.

Section 4 of the book deals with policy and policy-related issues. Brandt, Young, Alam, and Womack examine the role of foreign trade on the U.S. livestock market. The authors modeled the price impact of often dramatic changes (100-percent increase in net imports) in meat trade from 1985 levels and found the price impacts to be relatively small. The same four researchers examined how domestic farm policies affected livestock producers. As expected, the implications mirror changes in farm programs that significantly influence the price of corn. For example, going to a marketing loan approach on corn could allow corn prices to go down and reduce the slide in the size of the red meat industry but would bring added variance in farm-level net returns.

Margaret Zafiriou describes the Canadian experience with lean beef. Grades were changed in 1972 to encourage Canadian producers to produce beef with lower fat content. Zafiriou suggests increased consumer concerns over fat are significant in the United States but she concludes that the current (U.S.) grading system is flexible enough to meet needs of domestic demands.

Andrew Schmitz discusses the two efforts by Brandt and others and the Zafiriou paper. He notes the complexity of the international scene with such paradoxes as the United States both importing and exporting beef. Schmitz says that beef is not a homogeneous commodity, but he appears to feel that foreign trade can be more important than do Brandt and his colleagues. Schmitz also questions whether the impact of one of the extreme farm policy alternatives (sharply lower grain prices) would be as extensive as the authors had suggested. He wonders whether lower grain prices, in response to a U.S. policy position, would stimulate expansion in a cattle industry whose future is seen to be uncertain by producers.

Lester Myers, in his summary for the entire book, expresses concern over what analysts can accomplish when he refers to the lack of a well-developed conceptual research base for assessing how consumers assimilate information and translate it into behavior. Myers concludes that a careful review of the papers should be useful to marketing strategists for red meat. But, there are dimensions of this entire issue that deserve more attention, and those dimensions belong in a review of the book in its entirety.

The book is essentially an indirect call for a re-examination of modeling techniques. There are apparent conflicts and inconsistencies. Huang and Haidacher "explain," via their model, 95 percent of the variation in per capita consumption through 1983, but Capps

The reports include: (1) "The Demand for Meat: Symposium Objectives" by Richard Haidacher; (2) "What is America Eating and What is Happening to Meat Consumption?" by Reuben Buse; (3) "ERS's Measures of Red Meat Comsumption" by Kenneth Nelson and Lawrence Duewer; (4) "Cross-Sectional Data for Demand Analysis" by Ronald Schrimper; (5) "A Review of the Research Literature on Meat Demand" by David Smallwood, Richard Haidacher, and James Blaylock; (6) "On the Structure of Demand for Meat" by Jean-Paul Chavas; (7) "An Assessment of Price and Income Effects on Changes in Meat Consumption" by Kuo Huang and Richard Haidacher; (8) "Have Meat Price and Income Elasticities Changed? Their Connection with Changes in Marketing Channels" by Walter Thurman; (9) "Effects of the Changing Composition of Beef Consumption on the Elasticities for Beef and Poultry" by Michael Wohlgenant; (10) "Is U.S. Meat Demand in Equilibrium?" by Roger Dahlgren; (11) "Discussion: Structural Change in Meat Demand: The End of the 'Chicken Little' Era" by S. R. Johnson; (12) "Effect of Demographics on Changes in At-Home Meat Consumption" by Thomas Cox, Reuben Buse, and Antonio Alvarez; (13) "Effect of Sociodemographics on At-Home Red Meat Consumption in the United States" by Jong-Ying Lee; (14) "The Importance of Demographic Variables on the Probability of Consuming Meat Away from Home" by Vicki McCracken; (15) "Added Convenience as a Factor in At-Home Animal Products Demand" by Oral Capps, Jr.; (16) "Discussion: Effects of Demographic Factors" by Ben Senauer; (17) "Foreign Trade and Its Impact on the Domestic Livestock Market" by Jon Brandt, Robert Young II, Shamsul Alam, and Abner Womack; (18) "The Impact of Domestic Policies and Programs on Producers of Meat and Animal Products" by Jon Brandt, Robert Young II, Shamsul Alam, and Abner Womack; (19) "The Canadian Experience with Lean Beef" by Margaret Zafiriou; (20) "Discussion: Livestock: Constraints and Opportunities" by Andrew Schmitz; and (21) "What Do We Know and What Does It Mean?" by Lester Myers.

finds evidence of an increasing demand for convenience and notes that red meats have lagged other meats in breadth and convenience in their product lines. Other researcher see a meaningful impact of demographic variables, finding significantly different parameter estimates (such as income elasticities) within the range of data (income levels), but the Huang-Haidacher model apparently restricted the elasticities to being constants over the entire 31-year analysis period.

Lester Myers referred to the tendency for the Huang-Haidacher model to overestimate consumption levels in the post-1980 period. Myers calls the bias (3-5 percent) in the estimates relatively small. But the conceptual and analytical problems typified by the Huang-Haidacher effort may not be small. A 5-percent "miss" when per capita consumption is around 80 pounds is 4 pounds, and that is a major error in predicting a series as stable as per capita consumption of beef.

Even more troubling is the essentially blind acceptance and use of such modeling efforts. A group of economists commissioned by the National Cattlemen's Association Task Force on Concentration/Integration used a version of the same model Huang had reported in 1985 (*U.S. Demand for Food: A Complete System of Price and Income Effects*, U.S. Dept. Agr., Econ. Res. Serv., TB-1714, Dec. 1985). The relevant coefficients estimated by Huang were employed in an updating effort through 1987. All of the residuals (predicted-actual) were positive from 1980 through 1987, with the errors as large as 4.8 percent. During 1954-79, 21 of the 26 residuals were negative and the residuals show negative "strings" of 7 (1958-64), and 7 again (1966-72). Clearly, this model did not accurately reflect the beef situation for the data period, especially for the critically important 1980's. Yet, the results with the R^2 of 95 were used to support a recommendation that the model ... leaves only a small proportion of the change in consumption patterns—probably no more than three percent—attributable to change in preferences." (D. Gale Johnson and others, p. 128).[1]

The conclusion that no significant preference shifts had occurred led to strong recommendations to reduce the price of beef via reduced costs. The authors also concluded that advertising would do little or no good without a lower priced product. Several sectors of the industry felt threatened by the recommendations. The need for programs to advertise and encourage development of new beef products was being questioned by critics who said that preference-related issues at the consumer level (health consciousness, lifestyles, and need for convenience) were not important. The only need, it was being argued, was to cut costs and lower the final price to consumers.

The issues and the questions continue, and that is why the book is highly recommended—not because it answers the difficult conceptual and analytical issues, but because it showcases the issues so clearly. On the one hand, reports of econometric models place severe restrictions on the "real world" via explicit or implicit assumptions and then proceed to use the results with no explicit concern for the restrictive assumptions. On the other hand, a recording of the demographics and all the other variable and potentially variable compo-

[1]D. Gale Johnson, J. Connor, J. Josling, A. Schmitz, G. Schuh. *Competitive Issues in the Beef Sector: Can Beef Compete in the 1990s?* Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, Minneapolis, Oct. 1989.

nents give reason to question the analytical techniques employed. The demand analyst needs to be exposed to that substantial scope of possibilities.

We have to deal with what was happening when the inflation-adjusted price of Choice beef at retail had to fall by over 30 percent from 1979 through 1986 to entice the consumer to continue buying what was essentially a constant per capita supply. The sharply lower prices for a constant supply of beef occurred in the presence of upward-trending real consumer incomes and in the presence of inflation-adjusted poultry and pork prices that increased relative to beef. That development was, it appears, the source of the consistent overestimation of the Huang model from 1980 through 1987. Any model that is incapable of registering a shift in demand (due to tastes, preferences, or whatever) above and beyond the influence of relative prices and incomes is not rigorous in a conceptual context. The results only look rigorous and sophisticated.

The book, then, is effective in what it sets out to do: to explore what we know about demand for meats and what it all means. In some areas, we know far too little. In other areas, we have perhaps convinced ourselves we know too much and have pushed too hard in application of models that are either incapable of registering shifts in demand due to preference-related changes or cannot recognize a shift until many years of changed consumer behavior patterns are included in the econometric models. But the industry can ill afford to wait for years for the models to conclude that demand has shifted. It is not a bad idea to start with these points in mind, and the book will move the discerning reader and would-be analyst in that direction.

Multiple Criteria: An Introduction But Read More

Multiple Criteria Analysis for Agricultural Decisions. *By C. Romero and T. Rehman. Amsterdam: Elsevier, 1989, 257 pages, $94.75.*

Reviewed by Elizabeth Erickson

Farmers and policymakers usually have more than one objective in mind when they make decisions. Agricultural economists find it easier to assume a single objective in their analyses. To be relevant, we need to change our approach, and there is an array of methods for us to use. This is the message of Romero and Rehman's book. It is an important one. Unfortunately, the authors are better at explaining the techniques than at generating the reader's interest in their application.

The problem is one of style rather than of substance. The initial section of the book provides a sound rationale for multiple criteria decisionmaking (MCDM). But the way Romero and Rehman write makes it difficult for readers to follow their arguments, much less to sustain interest in them. To make matters worse, there are innumerable grammatical and typographical errors, plus a camera-ready format which cannot be read easily.

These deficiencies in form are frustrating because, in terms of content, Romero and Rehman provide a useful introduction to MCDM techniques and the first text/reference for agricultural economists. Also, because of the style, the sense of enthusiasm found in other MCDM texts (for example, Zeleny, Cohon, and Goiocoechea and others) is missing.[1] MCDM is a growing field and the writing of its practitioners usually reflects their excitement in the possibilities of the methods.

The book covers the most commonly used MCDM techniques of goal programming, multiple-objective programming, compromise programming, and interactive techniques. The authors assume readers have some background in linear programming, and they reformulate a typical linear programming model to illustrate the various MCDM methods. At the end of each chapter, there is an assessment of the technique, plus a short review of the recent literature extending the methods and suggesting further readings. A final section of case studies includes a land reform problem, diets for cattle, fertilizer formulation, and a wine agribusiness.

Both strengths and weaknesses characterize Romero and Rehman's approach. To introduce a new field effectively, a book's content has to be organized so a new reader can make sense of it: to tie ideas together to make an integrated whole. This is not easy for a multi-disciplinary field that is still developing. Romero and Rehman's strength is in their coverage of each major technique. Each chapter strikes a balance between covering too many methods and too few, and between including detailed discussion of algorithms and none at all. The example problems are easy to follow (although the diagrams and tables could be clearer on occasion). The literature reviews for each technique are comprehensive and provide direction for further reading, a major requirement for a good reference.

The framework that could integrate all these parts is missing, unfortunately. In the second chapter, for example, the authors clarify the concepts of attributes, objectives, and goals to classify MCDM approaches. This is a useful first step, but the logical second one is to set the techniques within the broader context of decision analysis. Romero and Rehman assume implicitly that readers know classical utility theory and state the implications of lexicographic choice, ideal points, and distance metrics in terms of utility functions. But, where strict utility assumptions are not met, they imply that use of a technique is purely *ad hoc*. A look at Zeleny, Goiocoechea, or, more generally, Bell and others[2] would show that many MCDM methods can be put within the context of recent developments in decision theory, such as displaced ideals and reference points.

Equally useful would be a more organized approach to the whole question of how to decide which MCDM method to use in empirical analysis. Factors like computer time required and information overload are listed when techniques are evaluated, but Romero and Rehman fail to establish criteria for using and judging these factors (see Willis and Perlack).[3]

Effective integration does occur in some places. One interesting section uses different distance metrics to show that the various forms of goal programming and

Erickson is an associate professor, Department of Economics, University of Akron, Ohio.

[1]Milan Zeleny, *Multiple Criteria Decision Making*, New York: McGraw-Hill, 1982. J. L. Cohon, *Multiple-Objective Programming and Planning*, New York; Academic Press, 1978. Ambrose Goiocoechea, Don R. Hansen, and Lucien Duckstein, *Multiple Objective Decision Analysis with Engineering and Business Applications*, New York: John Wiley and Sons, 1982.

[2]David Bell, Howard Raiffa, and Amos Tversky. *Decision Making: Descriptive, Normative and Prescriptive Interactions*, Cambridge: Cambridge University Press, 1988.

[3]C.E. Willis and R.D. Perlack. "A Comparison of Generating Techniques and Goal Programming for Public Investment, Multiple Objective Decision Making," *American Journal of Agricultural Economics*, Vol. 62, No. 1, 1980, pp. 66-74.

multiple objective programming are just variants of compromise programming. (Incidentally, the book does provide an effective intuitive explanation of distance metrics which is not found in other texts.) The authors also point out that risk models are multiple-objective programming models with two objectives. Risk aversion can then be analyzed with compromise programming, where different distance metrics represent different utility functions.

One serious gap exists in what is otherwise a good first choice of MCDM models: the issue of public decisionmaking. Policymakers in agriculture have multiple and often conflicting goals, and analysts acknowledge he needs to include them in policy analysis. The trouble is that many policies do not directly affect goals. Options like price supports work indirectly through markets for products and factors. The usual multi-objective model is then inappropriate so we need to use a multi-level approach. In programming terms, that means maximization of the weighted objective function of decisonmakers is subject to the maximization of consumer plus producer surplus (market equilibrium). Effective algorithms to solve large-scale models of this type are hard to find (Candler and others), although heuristic methods have been used (Hazell and Norton, Erickson and House), and research continues.[4] As these references indicate, the issue of the multi-level model is well documented, but Romano and Rehman never mention the need to formulate most policy models in multi-level terms. In fairness, the examples they cite are in forestry and water management, where direct actions can be taken by Government agencies. Nevertheless, the gap is important, because, as Hazell and Norton point out, using the wrong model can give useless answers.

I have one final criticism. Romeno and Rehman do not address fully the question—why bother with MCDM? They do present a logical rationale for the techniques. For example, linear programming is just a special case of lexicographic goal programming, because all constraint goals must be met before the objective function goal is maximized or minimized. This model is an extreme case because many constraints are "soft" in practice. But one can ask, does it matter empirically? After all, including goals as extra constraints in a linear programming model may impose too rigid a requirement or too low a limit in theory. But are the answers very different in practice? A strong empirical case can be made for the use of MCDM, but Romero and Rehman do not present that case well. A patient reader can find some evidence in various chapters of the book. For example, when a linear program gives answers similar to that of a goal program, the goals may be set too low, an important point for normative analysis. The case studies, especially those using the diet problem, do make empirical estimates of the advantages of MCDM. But, Romero and Rehman do not present studies which provide the strongest empirical case for MCDM. One has to search their bibliography to find models from water management that examine environmental tradeoffs, for example.

Is Romero and Rehman's book worth reading? Yes, with a reservation—that the reader draw from the other material I have cited. Agricultural economists should be able to learn a range of MCDM techniques effectively from Romero and Rehman's book despite its style. I urge readers to look elsewhere to catch the excitement of MCDM and the breadth of its ideas.

This book at least provides a bibliographic guide for the search. Ask your library to buy this book. At about $95, you may not want to add it to your personal library or assign it as a text.

[4]Wilfred Candler, Jose Fortuny-Amat, and Bruce McCarl, "The Potential Role of Multi-Level Programming in Agricultural Economics," *American Journal of Agricultural Economics*, Vol. 63, No. 3, 1981, pp. 521-30. Peter B.R. Hazell and Roger D. Norton, *Mathematical Programming for Economic Analysis in Agriculture*, New York: Macmillan, 1986, ch. 7, 12. Elizabeth Erickson and Robert House, "Multiple Objective Analysis for a Spatial Market System: A Case Study of U.S. Agricultural Policy," *Spatial Price Equilibrium: Advances in Theory, Computation, and Application*, P. Harker (ed.), lecture notes in Economics and Mathematical Sciences 249, Springer-Verlag, 1985.

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Editors: W. L. Adamowicz, L. P. Apedaile and M. L. Lerohl, Department of Rural Economy, University of Alberta, Edmonton, Alberta, Canada T6G 2H1.

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